EPA REGION 4: PLANTS 5 AND 6

Plant Operations and Sampling

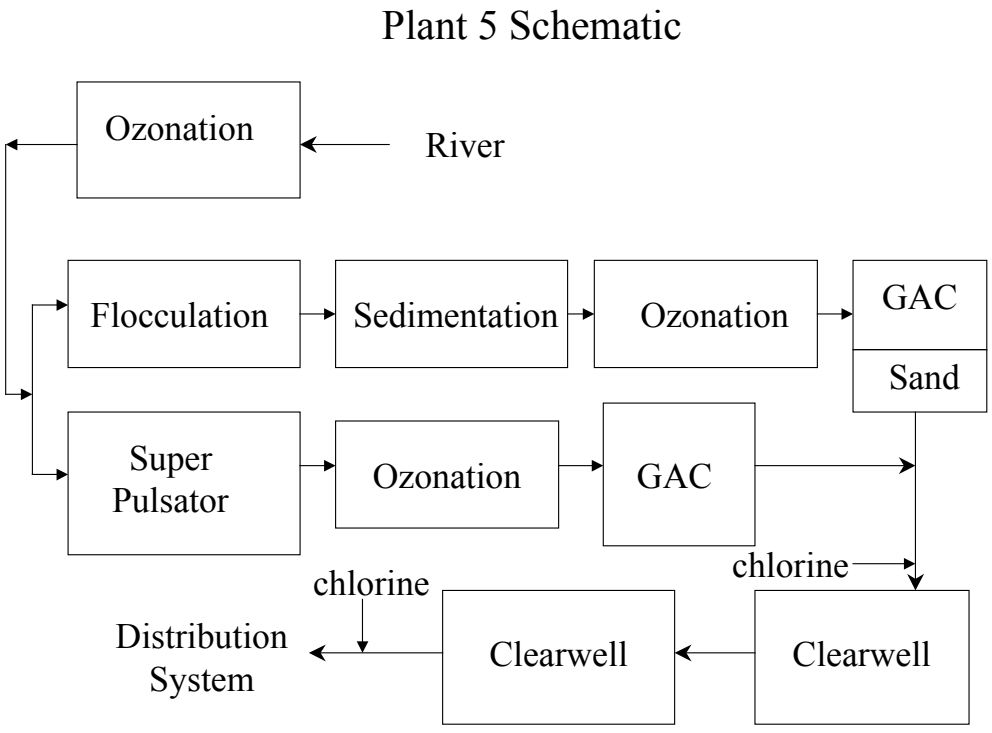
Plant 5 and plant 6 in EPA Region 4 treated water from the same river. On November 27, 2000, February 26, 2001, August 13, 2001, October 22, 2001, and April 15, 2002, these two plants were sampled

Plant 5 was an ozone plant (Figure 1). This plant consisted of two facilities operating simultaneously and parallel to one another:

- One was a conventional facility. After raw-water ozonation, the water underwent flocculation, coagulation, and sedimentation. The settled water then underwent intermediate ozonation. Ozonated settled water then entered biologically-activated filters, composed of granulated activated carbon (GAC) over sand.
- The other facility utilized solids contact – upflow clarification of coagulated water (Super Pulsator technology) following ozonation of the raw water. After clarification, the settled water underewent intermediate ozonation. Ozonated settled water then entered biologically activate filters, composed of deep-bed GAC filters.

Effluents from all of the filters were combined and final chemical adjustments were made. This included the addition of sodium hypochlorite for secondary disinfection and residual maintenance. Finished water then flowed first into one and then another closed reservoir for storage prior to being pumped into the distribution system.

Figure 1



Plant 5 was sampled at the following locations:

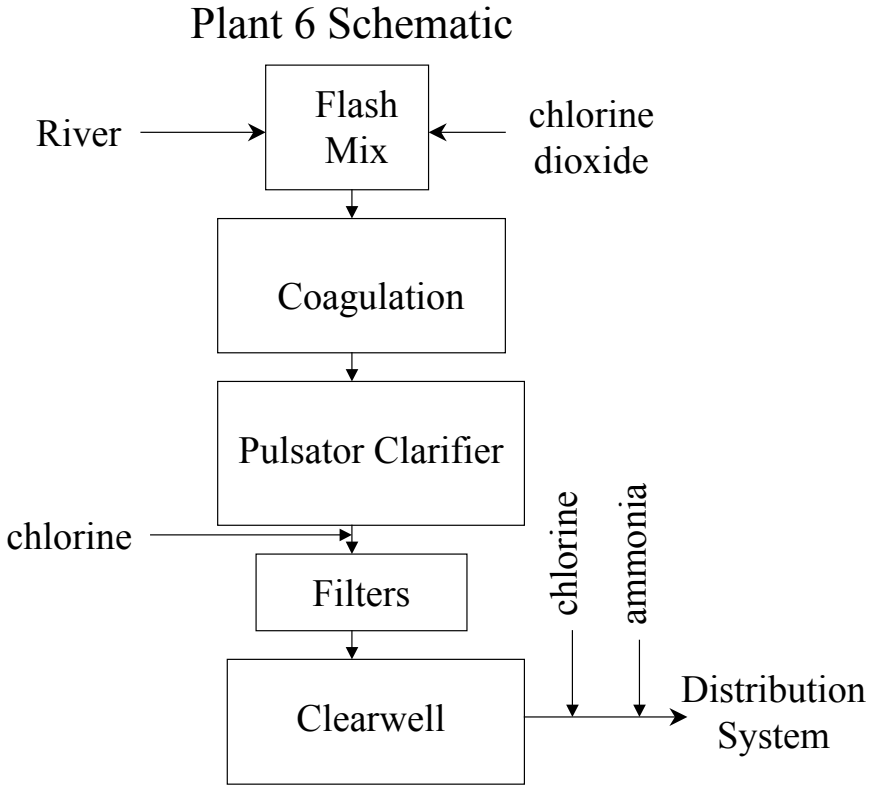
(1) raw water
(2) the effluent of the raw-water ozone contactor
(3) the GAC/sand influent on the conventional train
(4) the GAC/sand effluent on the conventional train
(5) the GAC influent on the Super Pulsator train
(6) the GAC effluent on the Super Pulsator train
(7) the composite filter effluent (on selected dates)
(8) the plant effluent

In addition, plant effluent was collected and simulated distribution system (SDS) testing was conducted for average and maximum detention times (Table 1). Furthermore, the distribution system was sampled at two locations, one representing an average detention time and the other representing a maximum detention time.

Plant 6 was a chlorine dioxide plant (Figure 2):

- After disinfection of the raw water with chlorine dioxide, the water underwent coagulation and clarification. The settled water was then chlorinated and filtered. Filtered water was then chloraminated and distributed.
- Starting with the August 2001 sampling, plant 6 moved their chlorine dioxide feed point up-stream of the plant. In November 2000 and February 2001, chlorine dioxide had been fed at the flash mixers. Plant 6 gained approximately 7-10 minutes of contact time (depending on flow) by adding the new feed point.

Figure 2



Plant 6 was sampled at the following locations:

(1) raw water
(2) settled water
(3) filter effluent
(4) clearwell effluent
(5) the plant effluent

In addition, plant effluent was collected and SDS testing was conducted for average and maximum detention times for that time of the year. Furthermore, the distribution system was sampled at two locations, one representing an average detention time and the other representing a maximum detention time.

Table 1. SDS holding times (days) at plants 5 and 6

Sample	11/27/00	2/26/01	8/13/01	10/22/01	4/15/02
Plant 5 average detention time	2.9	2.9	3.1	4	5.3
Plant 5 maximum detention time	6	6	7	8	7
Plant 6 average detention time	4	4	4	4	3
Plant 6 maximum detention time	7	7	7	7	7

On the day of sampling, information was collected on the operations at each plant (Tables 2-3).

Table 2. Operational information at plant 5

Parameter	11/27/00	2/26/01	8/13/01	10/22/01	4/15/02
Overall plant flow (mgd)	25[a]	12.3	19.35	17.26	17.4
Plant flow for conventional coag. train (mgd)	15[a]	6.0	9.97	9.41	7.59
Plant flow for Super Pulsator train (mgd)	10[a]	6.3	9.38	7.85	9.81
Raw-Water Ozone Contactor					
Ozone dose (mg/L)	4.33	3.4	3.90	2.80	4.50
CT (mg/L-min) achieved from ozonation	NA[b]	NA	NA	NA	9.0
Conventional Train					
Coagulant[c] (mg/L)	29.5	31	41.6	40.5	40.32
Ozone dose (mg/L)	3.98	1.0	2.30	2.20	2.52
Hydraulic retention time (t_{10}) in ozone contactor (min)	~20	~20	~20	~20	~20
CT (mg/L-min) achieved from ozonation	NA	NA	NA	7.0	7.0
GAC/sand filter loading rate (gpm/sq ft)	1.18	0.96	1.63	1.47	1.25
Super Pulsator Train					
Coagulant (mg/L)	38.4	29	46.7	45.7	45.4
Ozone dose (mg/L)	2.03	0.5	1.50	0.90	2.52
t_{10} in ozone contactor (min)	~20	~20	20	20	20
CT (mg/L-min) achieved from ozonation	NA	NA	NA	7.0	7.0
GAC filter loading rate (gpm/sq ft)	1.29	1.9	3.13	2.65	3.38
Composite Filter Effluent					
Chlorine dose at filter effluent (mg/L as Cl_2)	1.7	1.8	4.0	4.1	2.53
Chlorine dose at clearwell effluent (mg/L as Cl_2)	~2.0	1.6	1.5	1.9	1.02

[a]Design flows [b]NA = Not available [c]Alum [$Al_2(SO_4)_3$ $14H_2O$]

Table 3. Operational information at plant 6

Parameter	11/27/00	2/26/01	8/13/01	10/22/01	4/15/02
Plant flow (mgd)	8	8.2	9	8	7
Coagulant[a] (mg/L wet; mg/L dry)	16	18	38; ~19	32; 16	53; 26.5
Chlorine dioxide dose (mg/L as ClO_2)	1.95	1.5	1.98	2.1	1.5
Chlorine dose at filter influent (mg/L as Cl_2)	0.60	0.66	2.5	1.5	1.11
Chlorine dose at clearwell eff. (mg/L as Cl_2)	3.2	2.5	2.7	3.0	3.0
Ammonia dose at plant eff. (mg/L as NH_3-N)	1.0	0.76	0.87	1.0	1.0

[a]PAX 18 polyaluminum chloride [Al(OH)Cl] (17 % as Al_2O_3)

Water Quality

On the day of sampling, information was also collected on the water quality at each plant (Tables 4-5).

Data were collected for total organic carbon (TOC) and ultraviolet (UV) absorbance (Tables 6-7). The TOC ranged from 6.2 to 10 mg/L at plant 5 and from 6.4 to 10 mg/L at plant 6. The UV was 0.19 to 0.35 cm^{-1} at plant 5 and was 0.19 to 0.30 cm^{-1} at plant 6.

At plant 5, pre-ozonation reduced the level of TOC by 0-29 %, whereas the UV was reduced by 20-67 %. In the Super Pulsator treatment train, coagulation removed 43-54 % of the TOC and GAC filtration removed another 5-23 %. Coagulation reduced the UV by 63-83 %. The overall (cumulative) removal of TOC at the Super Pulsator treatment train—including from pre-ozonation—was 58-65 %, and the UV reduction was 85-93 %. The overall (cumulative) removal of TOC at the conventional train—including from pre-ozonation—was 62-69 %, and the UV reduction was 85-95 %.

At plant 6, coagulation removed 38-57 % of the TOC and filtration removed another 4-7 %. Coagulation reduced the UV by 68-77 %.

Table 8 shows the values of miscellaneous other water quality parameters in raw water at the two plants. Bromide ranged from 0.05 to 0.08 mg/L at plant 5 and from 0.04 to 0.08 mg/L at plant 6. For plant 5, the raw water was collected 23 miles upstream to eliminate the intake of salty water due to tidal changes. However, the presence of bromide in the raw water, which was higher in concentration in the fall, may indicate some saltwater intrusion.

The source water was low in alkalinity. Because of the low alkalinity, settled water (after the addition of coagulant) was acidic (Tables 4-5).

Table 4. Water quality information at plant 5

	pH					Temperature (ºC)					Disinfectant Residual[a] (mg/L)				
Location[b]	11/27/00	2/26/01	8/13/01	10/22/01	4/15/02	11/27/00	2/26/01	8/13/01	10/22/01	4/15/02	11/27/00	2/26/01	8/13/01	10/22/01	4/15/02
Raw water	6.8	6.5	6.4	6.6	6.2	13.8	16	29	21	21	---	---	---	---	---
Pre-O_3 eff.	6.8	6.6	6.4	6.5	6.2	13.0	16	29	22	21	**ND**[c]	**ND**	**ND**	**ND**	**ND**
Conventional Train															
GAC/s inf.	5.8	5.6	5.7	5.8	5.6	11.9	13	29	21	21	**ND**[d]	**0.05**	**0.08**	**0.1**	**0.09**
GAC/s eff.	5.9	5.6	5.7	5.9	5.7	12.0	13	29	22	20	---	---	---	---	---
Super Pulsator Train															
GAC inf.	5.9	5.7	5.7	5.7	5.6	11.9	12	29	21	21	**ND**[d]	**0.04**	**0.09**	**0.08**	**0.1**
GAC eff.	5.9	5.6	5.7	5.7	5.6	12.0	13	29	22	21	---	---	---	---	---
Composite Filter Effluent															
Filter eff.	5.9	NS[e]	NS	NS	NS	13.4	NS	NS	NS	NS	---	NS	NS	NS	NS
Plant eff.	7.0	7.0	7.0	7.1	7.0	15.8	16	29	22	20	2.0	1.6	1.7	1.5	1.6
DS/ave.	7.0	7.5	7.0	7.5	7.0	15	12	28	24.9	18	1.8	0.8	1.2	0.4	1.0
DS/max.	7.5	7.5	7.0	7.5	7.5	15	11	28	23.2	18	0.2	0.8	≤0.1	0.3	≤0.1
SDS/ave.	7.2	6.8	7.0	7.0	6.8	18	19	23.5	23	23	1.8	0.5	1.0	0.9	<0.1
SDS/max.	7.2	6.7	7.0	7.1	7.2	18	20	25.0	23	24	0.3	0.04	0.6	0.5	<0.1

[a]Ozone residuals (**values shown in bold**) in effluent of raw-water ozone contactor and in effluents of intermediate ozone contactors at GAC/sand and GAC influents; chlorine residuals at plant effluent, in distribution system, and in SDS testing.
[b]Pre-O_3 = raw-water ozone contactor, GAC/s = GAC/sand, DS = distribution system.
[c]ND = Not detected.
[d]Ozone sequestered with hydrogen peroxide prior to filtration.
[e]NS = Not sampled.

Table 5. Water quality information at plant 6

	pH					Temperature (ºC)					Disinfectant Residual[a] (mg/L)				
Location[b]	11/27/00	2/26/01	8/13/01	10/22/01	4/15/02	11/27/00	2/26/01	8/13/01	10/22/01	4/15/02	11/27/00	2/26/01	8/13/01	10/22/01	4/15/02
Raw water	7.0	6.9	6.5	7.0	6.7	13.0	13.6	28.4	19.9	18	---	**0.2**	---	---	---
Settled	6.6	6.4	6.2	6.7	6.2	13.4	13.8	27.3	19.8	20.2	**ND**/*0.2*	**0.04**	**0.02**	**.05**/*0.2*	**ND**
Filter eff.	6.5	6.7	7.4	7.5	8.0	13.0	12.6	28.1	20.3	19.9	**ND**/*0.4*	*0.3*	*0.5*/**.01**	*2.0*	*0.2*
Clearwell	7.0	6.8	6.9	7.1	6.9	12.8	12.4	28.5	20.1	19.0	**0.03**/*2.2*	*1.7*	*2.6*/**.02**	*2.2*	*2.9*
Plant eff.	7.1	6.8	7.2	7.2	7.1	13.9	12.5	27.4	20.5	20.9	2.2-2.6	2.2	2.9/**.05**	2.6	3.2
DS/ave.	7.3	7.2	7.1	7.9	6.8	12.0	12.0	27	21.0	18.4	2.0	1.7	2.2	1.4	3.2
DS/max.	7.7	7.4	7.5	8.1	7.4	13.0	12.0	26	21.0	18.3	0.9	1.2	1.5	1.3	1.8
SDS/ave.	7.3	NA	7.3	7.0	7.2	5.0	NA	28.5	20.3	21.8	2.1	NA	1.3	1.9	>2.2
SDS/max.	7.1	NA	7.2	7.0	6.9	5.0	NA	27.9	19.4	22.6	1.7	NA	1.1	1.4	2.0

[a]Chlorine dioxide residuals (**values shown in bold**) and chlorine residuals (values shown in italics) in raw water, settled water, filter effluent, clearwell effluent, and plant effluent; chloramine residuals (total chlorine residual as Cl_2) at plant effluent, in distribution system, and in SDS testing.
[b]DS = Distribution system

Table 6. TOC and UV removal at plant 5

Location	TOC (mg/L)	UV[a] (cm^{-1})	SUVA[b] (L/mg-m)	Removal/Unit (%)		Removal/Cumulative (%)	
				TOC	UV	TOC	UV
11/27/2000							
Raw	6.23	0.204	3.27	---	---	---	---
Pre-Ozone Eff.	6.07	0.157	2.59	2.6%	23%	2.6%	23%
GAC/Sand Inf.	3.22	0.024	0.75	47%	85%	48%	88%
GAC/Sand Eff.	2.24	0.019	0.85	30%	21%	64%	91%
GAC Inf.	2.88	0.026	0.90	53%	83%	54%	87%
GAC Eff.	2.22	0.019	0.86	23%	27%	64%	91%
02/26/2001							
Raw	7.44	0.244	3.28	---	---	---	---
Pre-Ozone Eff.	7.45	0.196	2.63	-0.1%	20%	-0.1%	20%
GAC/Sand Inf.	NR[b]	0.036	NA	NA	82%	NA	85%
GAC/Sand Eff.	2.81	0.030	1.07	NA	17%	62%	88%
GAC Inf.	3.41	0.035	1.03	54%	82%	54%	86%
GAC Eff.	3.14	0.033	1.05	7.9%	5.7%	58%	86%
08/13/2001							
Raw	7.26	0.251	3.46	---	---	---	---
Pre-Ozone Eff.	5.18	0.082	1.58	29%	67%	29%	67%
GAC/Sand Inf.	4.46	0.020	0.45	14%	76%	39%	92%
GAC/Sand Eff.	2.26	0.013	0.58	49%	35%	69%	95%
GAC Inf.	2.94	0.023	0.78	43%	72%	60%	91%
GAC Eff.	2.8	0.018	0.64	4.8%	22%	61%	93%
10/22/2001							
Raw	6.74	0.192	2.85	---	---	---	---
Pre-Ozone Eff.	5.26	0.082	1.56	22%	57%	22%	57%
GAC/Sand Inf.	3.22	0.029	0.90	39%	65%	52%	85%
GAC/Sand Eff.	2.45	0.028	1.14	24%	3.4%	64%	85%
GAC Inf.	2.87	0.030	1.05	45%	63%	57%	84%
GAC Eff.	2.66	0.029	1.09	7.3%	3.3%	61%	85%
04/15/2002							
Raw	10.28	0.351	3.41	---	---	---	---
Pre-Ozone Eff.	8.66	0.133	1.54	16%	62%	16%	62%
GAC/Sand Inf.	4.44	0.036	0.81	49%	73%	57%	90%
GAC/Sand Eff.	3.36	0.030	0.89	24%	17%	67%	91%
GAC Inf.	3.95	0.039	0.99	54%	71%	62%	89%
GAC Eff.	3.64	0.036	0.99	7.8%	7.7%	65%	90%

[a]UV = Ultraviolet absorbance reported in units of "inverse centimeters" (APHA, 1998)

[b]SUVA (L/mg-m) = Specific ultraviolet absorbance = 100*UV (cm^{-1})/DOC (mg/L) or UV (m^{-1})/DOC (mg/L), where DOC = dissolved organic carbon, which typically = 90-95% TOC (used TOC values in calculating SUVA) (e.g., UV = 0.204/cm = 0.204/(0.01 m) = 20.4/m, DOC = 6.23 mg/L, SUVA = (20.4 m^{-1})/(6.23 mg/L) = 3.27 L/mg-m)

[b]NR = Not reported; sample very turbid (white cloudy material that stayed in suspension)

Table 7. TOC and UV removal at plant 6

Location	TOC (mg/L)	UV[a] (cm^{-1})	SUVA[b] (L/mg-m)	Removal/Unit (%)		Removal/Cumulative (%)	
				TOC	UV	TOC	UV
11/27/2000							
Raw	6.36	0.210	3.30	---	---	---	---
Settled Water	3.76	0.062	1.65	41%	70%	41%	70%
Filter Eff.	3.51	0.058	1.65	6.6%	6.5%	45%	72%
02/26/2001							
Raw	8.09	0.261	3.23	---	---	---	---
Settled Water	4.24	0.070	1.65	48%	73%	48%	73%
Filter Eff.	3.99	0.069	1.73	5.9%	1.4%	51%	74%
08/13/2001							
Raw	7.86	0.264	3.36	---	---	---	---
Settled Water	4.7	0.085	1.81	40%	68%	40%	68%
Filter Eff.	4.53	0.070	1.55	3.6%	18%	42%	73%
10/22/2001							
Raw	6.66	0.189	2.84	---	---	---	---
Settled Water	4.16	0.071	1.71	38%	62%	38%	62%
Filter Effluent	3.93	0.066	1.68	5.5%	7.0%	41%	65%
04/15/2002							
Raw	9.5	0.305	3.21	---	---	---	---
Settled Water	4.07	0.070	1.72	57%	77%	57%	77%
Filter Effluent	3.88	0.062	1.60	4.7%	11%	59%	80%

Table 8. Miscellaneous water quality parameters in raw water at plant 5 and plant 6

Plant 5

Date	Bromide (mg/L)	Alkalinity (mg/L)	Ammonia (mg/L as N)
11/27/2000	0.08	26	ND
02/26/2001	0.047	22	ND
08/13/2001	0.06	19	ND
10/22/2001	0.08	28	0.04
04/15/2002	0.06	20	0.08

Plant 6

Date	Bromide (mg/L)	Alkalinity (mg/L)	Ammonia (mg/L as N)
11/27/2000	0.08	25	ND
02/26/2001	0.039	21	0.08
08/13/2001	0.05	20	ND
10/22/2001	0.08	27	ND
04/15/2002	0.06	20	0.05

DBPs

Oxyhalides. Tables 9-10 show the formation of oxyhalides at the two plants. At plant 5, ozonation resulted in the formation of from <3 to 6 μg/L of bromate when bromate was detected (Table 9). The conversion of bromide to bromate—when bromate was detected—was 2-5 % (on a molar basis), which is a typical conversion rate for an ozone plant operating for Giardia inactivation (Douville and Amy, 2000). Because the pH of ozonation was acidic (Table 4), bromate was often not detected, since low-pH ozonation minimizes bromate formation (Krasner

Table 9. Oxyhalide formation at Plant 5

Location	Bromate[a] (µg/L)	Chlorate (µg/L)	Bromate/Bromide (µmol/µmol)
11/27/2000			
Pre-Ozone Eff.	ND	5.8	---
Plant Eff.	3.8	79	3.0%
02/26/2001			
Pre-Ozone Effl.	ND	*4.6*	---
GAC/Sand Inf.	ND	8.4	---
GAC Inf.	ND	5.7	---
Plant Eff.	ND	45	---
08/13/2001			
Pre-Ozone Effl.	5	5	5.2%
GAC/Sand Inf.	ND	12	---
GAC Inf.	ND	14	---
Plant Eff.	ND	245	---
10/22/2001			
Pre-Ozone Effl.	5.6	ND	4.4%
GAC/Sand Inf.	*2.1*	ND	1.6%
GAC Inf.	ND	ND	---
Plant Eff.	*1.9*	162	1.5%
04/15/2002			
Pre-Ozone Effl.	3.5	ND	3.6%
GAC/Sand Inf.	*2.2*	ND	2.3%
GAC Inf.	ND	ND	---
Plant Eff.	*2.98*	184	3.1%

[a]Reporting detection level (RDL) for bromate = 3 µg/L; value in italics < RDL

Table 10. Oxyhalide formation at Plant 6

Location	Chlorite (µg/L)	Chlorate (µg/L)	ClO_2^-/ClO_2 %
11/27/2000			
Settled Water	1180	106	61%
Plant Eff.	1300	146	67%
02/26/2001			
Settled Water	783	69	51%
Plant Eff.	651	77	43%
08/13/2001			
Settled Water	772	137	39%
Clearwell Eff.	697	283	35%
10/22/2001			
Settled Water	1300	90	62%
Plant Eff.	1040	184	50%
04/15/2002			
Settled Water	765	100	51%
Plant Eff.	694	139	46%

et al., 1993). In addition, sodium hypochlorite can be contaminated with low or sub-µg/L levels of bromate (Delcomyn et al., 2000). Because the reporting detection level for bromate was 3 µg/L, it was not possible to determine if there was a significant increase in the concentration of bromate in the treated water after secondary disinfection. Low levels (<15 µg/L) of chlorate were detected at plant 5 until the plant effluent (Table 9). Chlorate was primarily introduced into the finished water after the secondary disinfection (chlorate is a by-product formed during the decomposition of the hypochlorite stock solution [Bolyard et al. [1992]).

It has been reported that during water treatment, approximately 50-70 % of the chlorine dioxide (ClO_2) reacted will immediately appear as chlorite (ClO_2^-) and the remainder as chloride (Aieta and Berg, 1986). An amount of chlorite consistent with this report was detected at plant 6 in the settled water (Table 10). The residual chlorite can continue to degrade in the water system. At plant 6, the concentration of chlorite was typically somewhat lower in the plant effluent, whereas the level of chlorate was somewhat higher.

Biodegradable Organic Matter. Ozone can convert natural organic matter in water to carboxylic acids (Kuo et al., 1996) and other assimilable organic carbon (AOC) (van der Kooij et al., 1982). Table 11 shows the carboxylic acid and AOC data for plant 5. Because AOC data are expressed in units of micrograms of carbon per liter (µg C/L), the carboxylic acid data were converted to the same units. A portion of the molecular weight (MW) of each carboxylic acid is due to carbon atoms (i.e., 27-49 %), and the remainder due to oxygen and hydrogen atoms. The sums of the five carboxylic acids (on a µg C/L basis) were compared to the AOC data. On a median basis for each sample date, 29 to 70 % of the AOC was accounted for by the carboxylic acids. For the raw-water sample in February 2001, >>100 % of the AOC was accounted for by the carboxylic acids. Because the amount of AOC in the raw water was low, this comparison was not as accurate as for the other samples in the plant.

Pre-ozonation significantly increased the concentration of the carboxylic acids (Table 11, Figure 3). In August 2001 (and in October 2001 and April 2002), formation of carboxylic acids (e.g., oxalate) was much higher during pre-ozonation (Table 11, Figure 4). The concentrations of the carboxylic acids were significantly decreased in both trains prior to the filters in August 2001 (Figure 3) (and in October 2001 and April 2002 [Table 11]). In the previous two samplings, the concentration of most of the carboxylic acids (e.g., oxalate) increased after intermediate ozonation (e.g., see GAC/sand influent data) (Figure 4). In the August 2001, October 2001, and April 2002 samplings, some of the carboxylic acids may have been removed during the coagulation process and/or biodegraded in the basins (Volk and LeChevallier, 2002). Biological filtration on the GAC/sand filters in the conventional treatment train and the GAC filters in the Super Pulsator treatment train resulted in further removal of the carboxylic acids that were present in the filter influent (Table 11, Figures 3-4). Moreover, the residual amount of carboxylic acids (e.g., oxalate) in the filtered water was somewhat similar in each season regardless of the level produced by the ozonation process (Table 11, Figure 3).

Table 11. Formation and removal of carboxylic acids and AOC at plant 5

	Concentration[a] (µg/L)					Concentration (µg C/L)							Sum/
Location	Acetate	Propionate	Formate	Pyruvate	Oxalate	Acetate	Propionate	Formate	Pyruvate	Oxalate	Sum	AOC	AOC
11/27/2000													
Raw	*5.0*	*6.5*	*8.3*	ND[b]	17	*2.0*	*3.2*	*2.2*	ND	4.7	12	18	68%
Pre-Ozone Eff.	37	ND	120	38	185	15	ND	32	16	50	113		
GAC/Sand Inf.	127	*9.4*	244	20	328	52	*4.6*	65	8.3	89	219	420	52%
GAC/Sand Eff.	19	ND	50	19	52	7.6	ND	13	8.0	14	43		
GAC Inf.	98	ND	202	ND	220	40	ND	54	ND	60	154	428	36%
GAC Eff.	18	ND	38	17	51	7.4	ND	10	7.2	14	38	349	11%
												median	44%
02/26/2001													
Raw	20	ND	42	22	43	8.1	ND	11	9.1	12	40	13	310%
Pre-Ozone Eff.	28	ND	34	27	398	11	ND	9.1	11	109	140		
GAC/Sand Inf.	136	ND	313	79	468	55	ND	83	33	128	299	430	70%
GAC/Sand Eff.	31	ND	66	26	67	13	ND	18	11	18	59		
GAC Inf.	NR[c]	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	331	
GAC Eff.	15	ND	22	ND	72	6.1	ND	5.9	ND	20	32	237	13%
												median	70%
08/13/2001													
Raw	17	ND	*11*	ND	24	6.9	ND	*2.9*	ND	6.5	16	38	44%
Pre-Ozone Eff.	600	ND	880	94	1800	244	ND	235	39	491	1009		
GAC/Sand Inf.	156	ND	264	53	472	63	ND	70	22	129	285	329	87%
GAC/Sand Eff.	37	ND	57	*8.5*	49	15	ND	15	*3.5*	13	47		
GAC Inf.	54	ND	78	19	159	22	ND	21	7.9	43	94	218	43%
GAC Eff.	32	ND	44	*13*	58	13	ND	12	*5.4*	16	46	87	53%
												median	48%
10/22/2001													
Raw	*9.6*	ND	*8.1*	ND	16	*3.9*	ND	*2.2*	ND	4.4	10	31	34%
Pre-Ozone Eff.	174	*3.1*	367	82	857	71	*1.5*	98	34	234	438		
GAC/Sand Inf.	111	ND	193	37	312	45	ND	51	15	85	197	759	26%
GAC/Sand Eff.	21	ND	40	*8.4*	45	8.5	ND	11	*3.5*	12	35		
GAC Inf.	25	ND	52	*9.7*	66	10	ND	14	*4.0*	18	46	161	29%
GAC Eff.	37	ND	36	*7.1*	33	15	ND	9.6	*2.9*	9.0	37	128	29%
												median	29%
04/15/2002													
Raw	*7.4*	ND	17	*9.0*	30	*3.0*	ND	4.5	*3.7*	8.2	19	46	42%
Pre-Ozone Eff.	343	*5.2*	618	88	2021	140	*2.6*	165	36	551	894		
GAC/Sand Inf.	159	*4.8*	235	69	713	65	*2.4*	63	29	194	353	317	111%
GAC/Sand Eff.	37	ND	72	22	101	15	ND	19	9.1	28	71		
GAC Inf.	71	ND	137	36	286	29	ND	37	15	78	158	553	29%
GAC Eff.	31	ND	82	23	88	13	ND	22	9.5	24	68	315	22%
												median	35%
Formula	CH_3COO^-	$CH_3CH_2COO^-$	$HCOO^-$	CH_3COCOO^-	$C_2O_4^{2-}$								
MW (gm/mole)	59	73	45	87	88								
C portion (gm/mole)	24	36	12	36	24								
C% of MW	41%	49%	27%	41%	27%								

[a]Method detection limit (MDL) = 3 µg/L; reporting detection level (RDL) = 15 µg/L; value in italics is < RDL

[b]ND = Not detected, value is < MDL

[c]NR = Not reported; apparent problems with the results of this sample

Figure 3

Formation and Removal of Carboxylic Acids at Plant 5
(August 13, 2001)

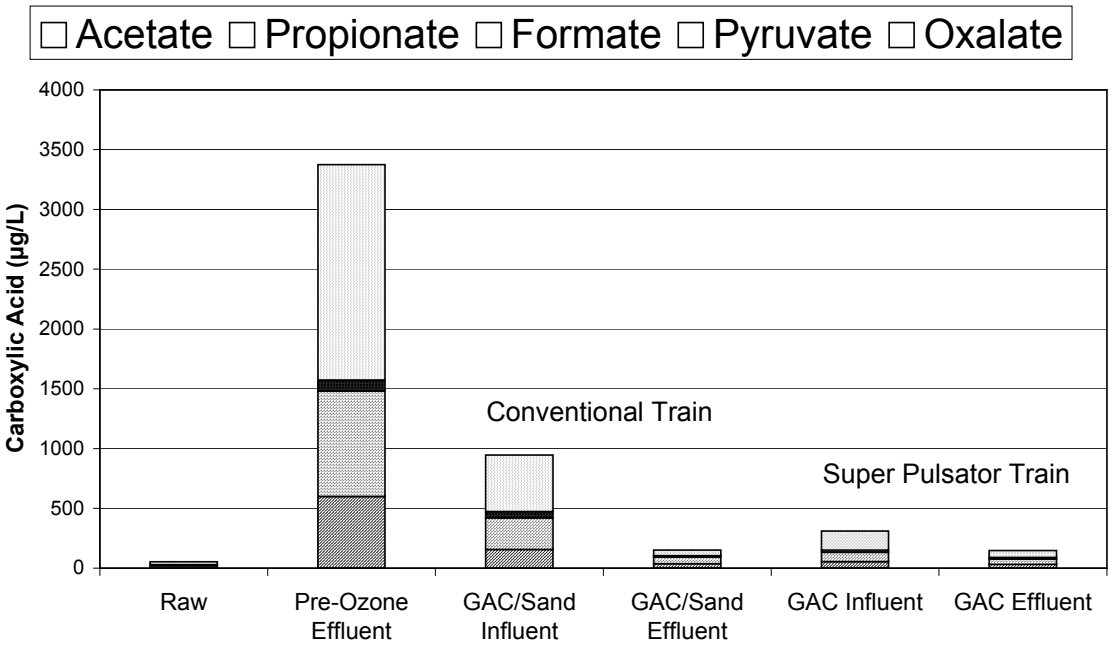
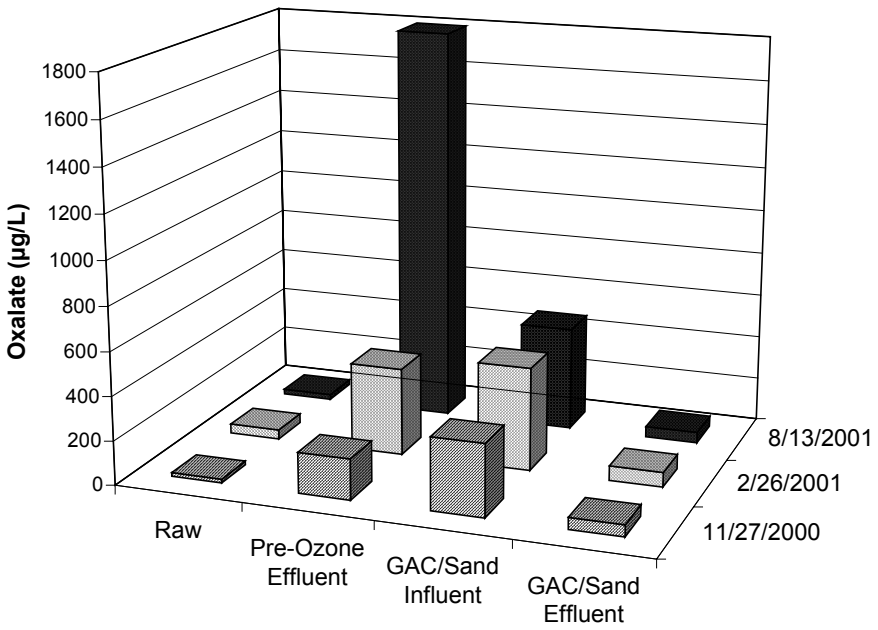


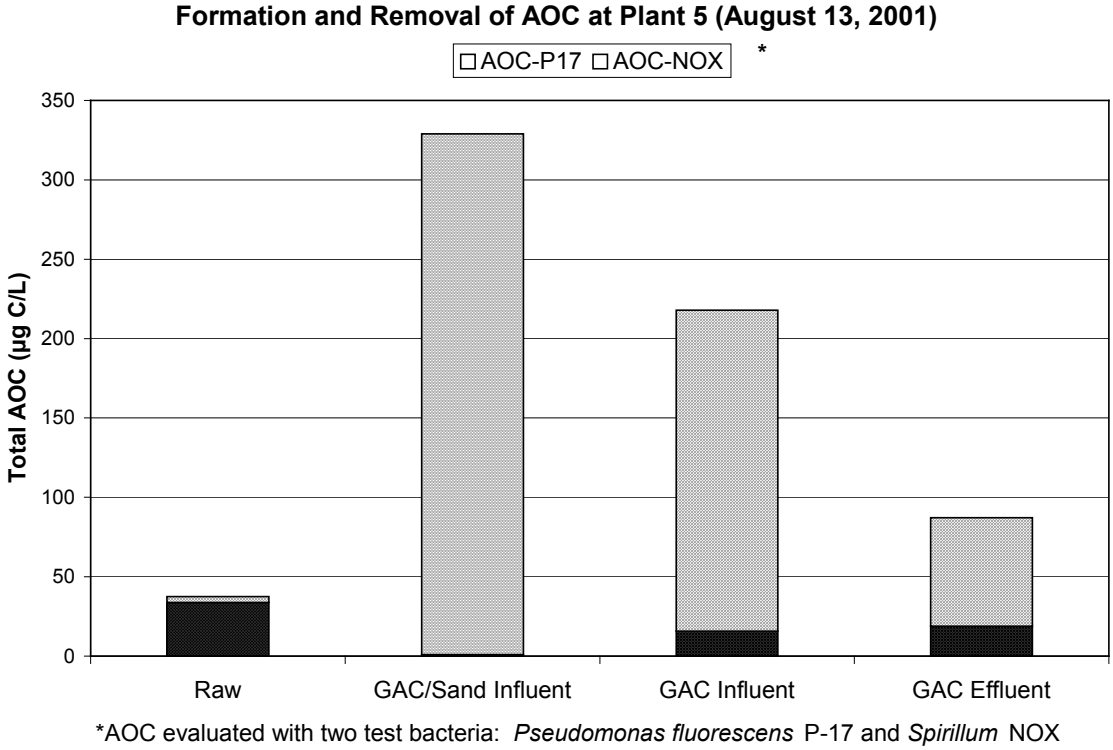
Figure 4

Seasonal Variation in Formation and Degradation
of Oxalate at Plant 5



Ozonation resulted in a significant increase in the concentration of AOC (Table 11, Figure 5). (Note, one of the bacterial strains used in the AOC method [i.e., *Spirillum NOX*] is used to estimate oxalate-carbon equivalents of the AOC [van der Kooij and Hijnen, 1984].) In August 2001, there was a significant reduction in the AOC on the GAC filter in the Super Pulsator train. (AOC was not sampled at the GAC/sand filter effluent in the conventional train, but based on carboxylic acid data [Figure 3], AOC should have been reduced in concentration.) In the other seasons, there was less AOC removal. The higher removal in August 2001 may have been due, in part, to the higher water temperature in the summer, which would have supported more biological activity.

Figure 5



Halogenated Organic and Other Nonhalogenated Organic DBPs. Tables 12 and 13 (11/27/00), Tables 15 and 16 (2/26/01), Tables 18 and 19 (8/13/01), Tables 22 and 23 (10/22/01), and Tables 24 and 25 (4/15/02) show results for the halogenated organic DBPs that were analyzed at Metropolitan Water District of Southern California (MWDSC). Table 14 (11/27/00), Table 20 (8/13/01), and Table 26 (4/15/02) show results for additional target DBPs that were analyzed for at the University of North Carolina (UNC). Table 17 (2/26/01 [plant 6] and 10/22/01 [plant 5]) shows results from broadscreen DBP analyses conducted at the U.S. Environmental Protection Agency (USEPA). Table 21 (8/13/01) and Table 27 (4/15/02) show results for halogenated furanones that were analyzed at UNC.

Table 12. DBP results at Plant 5 (11/27/00)

11/27/2000	MRL[a]	Plant 5[b]							
Compound	µg/L	Raw	GAC/Sand Inf	GAC Inf	Plant Eff	DS/Ave	DS/Max	SDS/Ave	SDS/Max
Halomethanes									
Chloromethane	0.15	ND[c]			ND	ND		ND	
Bromomethane	0.20	ND			ND	ND		ND	
Bromochloromethane	0.14	ND			ND	ND		ND	
Dibromomethane	0.11	ND			ND	ND		ND	
Chloroform[d]	0.10	0.8	NR[e]	NR	12	15	NR	48	NR
Bromodichloromethane[d]	0.10	0.3	NR	NR	14	16	NR	30	NR
Dibromochloromethane[d]	0.12	0.2	NR	NR	13	15	NR	16	NR
Bromoform[d]	0.12	ND	NR	NR	2	2	NR	2	NR
THM4[f]		1.3	NR	NR	41	48	NR	96	NR
Dichloroiodomethane	0.25	ND	NR	NR	ND	ND	NR	ND	NR
Bromochloroiodomethane	3	ND	ND	ND	<3[g]	<3	NR	<1[h]	NR
Dibromoiodomethane	0.64	ND	ND	ND	ND	ND	ND	ND	ND
Chlorodiiodomethane	0.10	ND	ND	ND	ND	ND	ND	ND	ND
Bromodiiodomethane	0.12	ND	ND	ND	ND	ND	ND	ND	ND
Iodoform	3	ND	ND	ND	ND	ND	NR	ND	NR
Carbon tetrachloride	0.06	ND			ND	ND		ND	
Haloacetic acids									
Monochloroacetic acid[d]	2				3.5	3.5		3.4	
Monobromoacetic acid[d]	1				ND	ND		ND	
Dichloroacetic acid[d]	1				8.7	9.8		22	
Bromochloroacetic acid[d]	1				7.0	7.7		12	
Dibromoacetic acid[d]	1				2.2	2.5		4.9	
Trichloroacetic acid[d]	1				3.8	5.3		9.0	
Bromodichloroacetic acid	1				5.7	7.0		8.1	
Dibromochloroacetic acid	1				2.9	3.4		4.2	
Tribromoacetic acid	2				ND	ND		ND	
HAA5[i]					18	21		39	
HAA9[j]					34	39		64	
DXAA[k]					18	20		39	
TXAA[l]					12	16		21	
Haloacetonitriles									
Chloroacetonitrile	0.10	ND	ND	ND	0.1	0.2	ND	ND	ND
Bromoacetonitrile	0.10	ND	0.2	ND	0.1	ND	ND	ND	ND
Dichloroacetonitrile[d]	0.10	ND	ND	ND	1	1	2	2	2
Bromochloroacetonitrile[d]	0.10	ND	ND	ND	1	1	2	2	2
Dibromoacetonitrile[d]	0.10	ND	ND	ND	0.7	0.7	0.9	0.9	0.8
Trichloroacetonitrile[d]	0.10	ND	ND	ND	ND	ND	ND	ND	ND
Haloacetaldehydes									
Dichloroacetaldehyde	0.16	ND	ND	ND	1	1	1	1	1
Bromochloroacetaldehyde[m] Chloral hydrate[d]	0.20	ND	ND	ND	6	7	21	27	29
Tribromoacetaldehyde	0.10	ND	ND	ND	0.1	0.1	ND	ND	ND

Table 12 (continued)

11/27/2000	MRL[a]	Plant 5[b]							
Compound	µg/L	Raw	GAC/Sand Inf	GAC Inf	Plant Eff	DS/Ave	DS/Max	SDS/Ave	SDS/Max
Haloketones									
Chloropropanone	0.10	ND	ND	ND	0.3	0.2	0.3	0.2	0.3
1,1-Dichloropropanone[d]	0.10	ND	ND	ND	0.5	0.4	0.2	0.2	ND
1,3-Dichloropropanone	0.10	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dibromopropanone	3	ND			ND	ND		ND	
1,1,1-Trichloropropanone[d]	0.10	ND	ND	ND	4	4	8	9	8
1,1,3-Trichloropropanone	0.10	ND	ND	ND	ND	ND	ND	ND	ND
1-Bromo-1,1-dichloropropanone	3	ND			<3	3		<1	
1,1,1-Tribromopropanone	3	ND			ND	ND		ND	
1,1,3-Tribromopropanone	3	ND			ND	ND		ND	
1,1,3,3-Tetrachloropropanone	0.10	ND	ND	ND	ND	ND	ND	ND	ND
1,1,3,3-Tetrabromopropanone	0.10	ND	ND	ND	0.1	0.1	ND	ND	ND
Halonitromethanes									
Bromonitromethane	0.10	ND	ND	ND	ND	ND	ND	ND	ND
Dichloronitromethane	3	ND			ND	ND		<3	
Dibromonitromethane	0.10	ND	ND	ND	ND	ND	0.1	ND	ND
Chloropicrin[d]	0.10	ND	ND	ND	0.4	0.4	3	2	3
Miscellaneous Compounds									
Methyl ethyl ketone	1.90	ND			ND	ND		ND	
Methyl *tertiary* butyl ether	0.16	ND			ND	ND		ND	
Benzyl chloride	0.50	ND	ND	ND	ND	ND	NR	ND	NR

[a]MRL = Minimum reporting level, which equals method detection limit (MDL) or lowest calibration standard or concentration of blank

[b]Treatment plant sampled at (1) raw water, conventional train sampled at (2) GAC/sand influent, Super Pulsator train sampled at (3) GAC influent, (4) plant effluent, (5) DS at average detention time and (6) at maximum detention time, and (7) SDS testing of plant effluent held for average detention time and (8) held for maximum detention time.

[c]ND = Not detected at or above MRL

[d]DBP in the Information Collection Rule (ICR) (note: some utilities collected data for all 9 haloacetic acids for the ICR, but monitoring for only 6 haloacetic acids was required)

[e]NR = Not reported, due to interference problem on gas chromatograph or to problem with quality assurance

[f]THM4 = Sum of 4 THMs (chloroform, bromodichloromethane, dibromochloromethane, bromoform)

[g]<3: Concentration less than MRL of 3 µg/L

[h]<1: Concentration less than lowest calibration standard (i.e., 1 µg/L)

[i]HAA5 = Sum of 5 haloacetic acids (monochloro-, monobromo-, dichloro-, dibromo-, trichloroacetic acid)

[j]HAA9 = Sum of 9 haloacetic acids

[k]DXAA = Sum of dihaloacetic acids (dichloro-, bromochloro-, dibromoacetic acid)

[l]TXAA = Sum of trihaloacetic acids (trichloro-, bromodichloro-, dibromochoro-, tribromoacetic acid)

[m]Bromochloroacetaldehyde and chloral hydrate co-eulte; result = sum of 2 DBPs

Table 13. DBP results at Plant 6 (11/27/00)

11/27/2000	MRL[a]	Plant 6[n]								
Compound	µg/L	Raw	Settled	Filter Eff	Clearwell Eff	Plant Eff	DS/Ave	DS/Max	SDS/Ave	SDS/Max
Halomethanes										
Chloromethane	0.15	ND[c]		ND		ND	ND		ND	
Bromomethane	0.20	ND		ND		ND	ND		ND	
Bromochloromethane	0.14	ND		ND		ND	ND		ND	
Dibromomethane	0.11	ND		ND		ND	ND		ND	
Chloroform[d]	0.10	0.3	0.8	4	NR[e]	8	8	NR	10	NR
Bromodichloromethane[d]	0.10	0.3	1	4	NR	8	8	NR	9	NR
Dibromochloromethane[d]	0.12	ND	0.5	2	NR	5	5	NR	5	NR
Bromoform[d]	0.12	ND	ND	0.5	NR	1	1	NR	1	NR
THM4[f]		0.6	2	11	NR	22	22	NR	25	NR
Dichloroiodomethane	0.25	ND	NR	ND	NR	0.3	0.3	NR	0.4	NR
Bromochloroiodomethane	3	ND	NR	ND	NR	<3[g]	<3	NR	<1[h]	NR
Dibromoiodomethane	0.64	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorodiiodomethane	0.10	ND	ND	ND	ND	ND	ND	ND	0.1	0.2
Bromodiiodomethane	0.12	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iodoform	3	ND	NR	ND	NR	ND	ND	ND	ND	ND
Carbon tetrachloride	0.06	ND		ND		ND	ND		ND	
Haloacetic acids										
Monochloroacetic acid[d]	2		2.0	2.4	2.6	ND	2.3		2.2	
Monobromoacetic acid[d]	1		ND	ND	1.0	ND	ND		ND	
Dichloroacetic acid[d]	1		11	14	16	16	17		16	
Bromochloroacetic acid[d]	1		5.2	7.8	9.1	9.3	9.5		9.4	
Dibromoacetic acid[d]	1		ND	1.5	2.0	2.0	2.1		2.0	
Trichloroacetic acid[d]	1		ND	2.7	3.7	3.5	3.2		3.6	
Bromodichloroacetic acid	1		ND	1.7	2.1	2.0	1.9		2.0	
Dibromochloroacetic acid	1		ND	1.0	1.1	1.0	1.1		1.1	
Tribromoacetic acid	2		ND	ND	ND	ND	ND		ND	
HAA5[i]			13	20	25	22	25		24	
HAA9[j]			18	31	38	34	37		37	
DXAA[k]			16	23	27	28	29		28	
TXAA[l]			ND	5.4	6.9	6.5	6.2		6.7	
Haloacetonitriles										
Chloroacetonitrile	0.10	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoacetonitrile	0.10	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichloroacetonitrile[d]	0.10	ND	0.2	0.5	0.7	0.7	0.8	0.9	0.8	1
Bromochloroacetonitrile[d]	0.10	ND	0.1	0.3	0.4	0.4	0.4	0.6	0.5	0.5
Dibromoacetonitrile[d]	0.10	ND	ND	ND	0.1	0.1	0.1	0.1	0.1	0.1
Trichloroacetonitrile[d]	0.10	ND	ND	ND	ND	ND	ND	ND	ND	ND
Haloacetaldehydes										
Dichloroacetaldehyde	0.16	ND	0.6	1	1	2	2	5	2	2
Bromochloroacetaldehyde[m] Chloral hydrate[d]	0.20	ND	ND	1	2	2	2	3	2	2
Tribromoacetaldehyde	0.10	ND	ND	0.1	ND	ND	ND	ND	0.1	0.1

Table 13 (continued)

11/27/2000	MRL[a]	Plant 6[n]								
Compound	µg/L	Raw	Settled	Filter Eff	Clearwell Eff	Plant Eff	DS/Ave	DS/Max	SDS/Ave	SDS/Max
Haloketones										
Chloropropanone	0.10	ND	0.4	0.5	0.6	0.6	0.6	1	0.8	0.9
1,1-Dichloropropanone[d]	0.10	ND	0.5	0.9	1	1	1	2	1	2
1,3-Dichloropropanone	0.10	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dibromopropanone	3	ND		ND		ND	ND		ND	
1,1,1-Trichloropropanone[d]	0.10	ND	0.1	0.5	0.5	0.5	0.4	0.1	0.4	0.5
1,1,3-Trichloropropanone	0.10	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-Bromo-1,1-dichloropropanone	3	ND		<1		<1	<1		<1	
1,1,1-Tribromopropanone	3	ND		ND		ND	ND		ND	
1,1,3-Tribromopropanone	3	ND		ND		ND	ND		ND	
1,1,3,3-Tetrachloropropanone	0.10	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,3,3-Tetrabromopropanone	0.10	ND	ND	ND	ND	ND	ND	ND	ND	ND
Halonitromethanes										
Bromonitromethane	0.10	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichloronitromethane	3	ND		ND		ND	ND		<1	
Dibromonitromethane	0.10	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloropicrin [d]	0.10	ND	ND	ND	0.2	0.2	0.3	0.7	0.4	0.8
Miscellaneous Compounds										
Methyl ethyl ketone	1.90	ND		ND		ND	ND		ND	
Methyl *tertiary* butyl ether	0.16	ND		ND		ND	ND		ND	
Benzyl chloride	0.50	ND	NR	ND	NR	ND	ND	NR	ND	NR

[n]Treatment plant sampled at (1) raw water, (2) settled water, (3) filter effluent, (4) clearwell effluent, (5) plant effluent, (6) DS at average detention time and (7) at maximum detention time, and SDS testing of plant effluent (8) held for average detention time and (9) held for maximum detention time.

Table 14. Additional target DBP results (µg/L) at plants 5 and 6 (11/27/00)

11/27/2000	Plant 5[a]						Plant 6[b]					
Compound	Raw	OE1	Comb FE	PE	DS/ave	SDS/max	Raw	Settled	FE	PE	DS/ave	SDS/max
Monochloroacetaldehyde	0	0	0	0.2	0.1	0.6	0	0.6	0.7	0.3	0.4	0.3
Dichloroacetaldehyde	0	0	0	2.0	1.9	2.6	0	0.6	1.0	1.3	1.8	1.3
Bromochloroacetaldehyde	0	0	0	2.2	2.0	2.3	0	0.7	1.2	1.8	2.3	1.8
3,3-Dichloropropenoic acid	0.2	0.1	0.1	0.9	1.3	0.6	0.1	0.4	0.5	0.7	0.9	1.4
Bromochloromethylacetate	0	0	0	0	0	0	0	0	0	1.1	0	0
2,2-Dichloroacetamide	0	0	0	0	0	0	0	0	0	1.5	1.2	2.5
TOX (µg/L as Cl^-)	36.9		16.1	205	227	245	15.2	88.8	120	146	124	148
Cyanoformaldehyde	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1
5-Keto-1-hexanal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
6-Hydroxy-2-hexanone	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dimethyglyoxal	<0.4	0.7	3.2	2.1	2.1	2.1	<0.4	1.1	0.6	1.7	1.3	1.8
trans -2-Hexenal	<0.1	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

[a]OE1= Raw-water ozone contactor effluent, Comb FE = combined filter effluent, PE = plant effluent

[b]FE = Filter effluent, PE = plant effluent

Table 15. DBP results at plant 5 (2/26/01)

2/26/2001	MRL[a]	Plant 5[b]							
Compound	µg/L	Raw	GAC/Sand Inf	GAC Inf	Plant Eff	DS/Ave	DS/Max	SDS/Ave	SDS/Max
Halomethanes									
Chloromethane	0.15	ND[c]			ND	ND		ND	
Bromomethane	0.20	ND			ND	ND		ND	
Bromochloromethane	0.14	ND			ND	ND		ND	
Dibromomethane	0.11	ND			ND	ND		ND	
Chloroform[d]	0.1	0.1	ND	0.1	3	17	15	34	41
Bromodichloromethane[d]	0.1	ND	ND	ND	8	12	12	16	14
Dibromochloromethane[d]	0.10	ND	ND	ND	6	7	7	6	5
Bromoform[d]	0.12	ND	ND	ND	0.6	1	ND	0.6	ND
THM4[f]		0.1	ND	0.1	18	37	34	57	60
Dichloroiodomethane	0.25	ND	NR[e]	NR	0.3	0.3	NR	0.3	NR
Bromochloroiodomethane	0.20	ND	NR	NR	ND	ND	NR	ND	NR
Dibromoiodomethane	0.48	ND	NR	NR	ND	ND	NR	ND	NR
Chlorodiiodomethane	0.51	ND	ND	ND	ND	ND	ND	ND	ND
Bromodiiodomethane	0.56	ND	ND	ND	ND	ND	ND	ND	ND
Iodoform	0.54	ND	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	0.06	ND			ND	ND		ND	
Tribromochloromethane	0.5	ND	ND	ND	ND	ND	ND	ND	ND
Haloacetic acids									
Monochloroacetic acid[d]	2				ND	4.9		5.4	
Monobromoacetic acid[d]	1				ND	1.1		ND	
Dichloroacetic acid[d]	1				9.8	16		20	
Bromochloroacetic acid[d]	1				5.0	9.2		7.4	
Dibromoacetic acid[d]	1				1.2	2.8		1.5	
Trichloroacetic acid[d]	1				4.8	13		8.5	
Bromodichloroacetic acid	1				4.8	10		5.1	
Dibromochloroacetic acid	1				2.2	3.4		1.9	
Tribromoacetic acid	2				ND	ND		ND	
HAA5[i]					16	38		35	
HAA9[j]					28	60		50	
DXAA[k]					16	28		29	
TXAA[l]					12	26		16	
Haloacetonitriles									
Chloroacetonitrile	0.1	ND	ND	ND	0.1	0.2	0.2	0.3	0.3
Bromoacetonitrile	0.1	ND	ND	ND	ND	ND	ND	ND	ND
Dichloroacetonitrile[d]	0.10	ND	ND	ND	1	1	1	2	2
Bromochloroacetonitrile[d]	0.1	ND	ND	ND	0.8	0.8	0.8	1	0.8
Dibromoacetonitrile[d]	0.17	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroacetonitrile[d]	0.1	ND	ND	ND	ND	ND	ND	ND	ND
Haloacetaldehydes									
Dichloroacetaldehyde	0.16	ND	ND	0.2	0.7	0.5	0.5	0.7	0.5
Bromochloroacetaldehyde	0.1	ND	ND	ND	0.4	0.3	0.2	0.2	0.1
Chloral hydrate[d]	0.1	ND	ND	ND	3	5	5	9	10
Tribromoacetaldehyde	0.1	ND	ND	ND	ND	ND	ND	ND	ND

Table 15 (continued)

2/26/2001	MRL[a]	Plant 5[b]							
Compound	µg/L	Raw	GAC/Sand Inf	GAC Inf	Plant Eff	DS/Ave	DS/Max	SDS/Ave	SDS/Max
Haloketones									
Chloropropanone	0.5	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropanone[d]	0.11	ND	ND	ND	0.5	0.2	0.2	0.3	0.2
1,3-Dichloropropanone	0.10	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dibromopropanone	3	ND			ND	ND		ND	
1,3-Dibromopropanone	3	ND			ND	ND		ND	
1,1,1-Trichloropropanone[d]	0.10	ND	ND	ND	3	4	4	8	6
1,1,3-Trichloropropanone	0.11	ND	ND	ND	0.1	ND	ND	ND	ND
1-Bromo-1,1-dichloropropanone	3	ND			<3[g]	<1[h]		<1	
1,1,1-Tribromopropanone	3	ND			ND	ND		ND	
1,1,3-Tribromopropanone	3	ND			ND	ND		ND	
1,1,3,3-Tetrachloropropanone	0.12	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1,3-Tetrachloropropanone	3	ND			<1	<1		<1	
1,1,3,3-Tetrabromopropanone	0.12	ND	ND	ND	ND	ND	ND	ND	ND
Halonitromethanes									
Bromonitromethane	0.1	ND	ND	ND	ND	ND	ND	ND	ND
Dichloronitromethane	3	ND			<1	<3		<1	
Bromochloronitromethane	3	ND			<3	3		<3	
Dibromonitromethane	0.12	ND	ND	ND	0.2	0.2	0.2	0.1	0.1
Chloropicrin[d]	0.1	ND	ND	ND	0.2	1	0.9	0.9	1
Miscellaneous Compounds									
Methyl ethyl ketone	1.90	ND			ND	ND		ND	
Methyl *tertiary* butyl ether	0.16	ND			ND	ND		ND	
Benzyl chloride	2	ND	ND	ND	ND	ND	ND	ND	ND

Table 16. DBP results at plant 6 (2/26/01)

2/26/2001	MRL[a]	Plant 6[n]								
Compound	µg/L	Raw	Settled	Filter Eff	Clearwell Eff	Plant Eff	DS/Ave	DS/Max	SDS/Ave	SDS/Max
Halomethanes										
Chloromethane	0.15	ND[c]		ND		ND	ND		ND	
Bromomethane	0.20	ND		ND		ND	ND		ND	
Bromochloromethane	0.14	ND		ND		ND	ND		ND	
Dibromomethane	0.11	ND		ND		ND	ND		ND	
Chloroform[d]	0.1	0.1	0.2	1	1	2	5	1	2	2
Bromodichloromethane[d]	0.1	ND	0.1	0.8	2	2	5	4	3	3
Dibromochloromethane[d]	0.10	ND	ND	0.2	0.6	0.4	1	1	0.6	0.6
Bromoform[d]	0.12	ND	ND	ND	ND	ND	ND	ND	ND	ND
THM4[f]		0.1	0.3	2	4	4	11	6	6	6
Dichloroiodomethane	0.25	ND	NR[e]	0.2	NR	0.3	0.4	NR	0.3	NR
Bromochloroiodomethane	0.20	ND	NR	ND	NR	ND	ND	NR	ND	NR
Dibromoiodomethane	0.48	ND	NR	ND	NR	ND	ND	NR	ND	NR
Chlorodiiodomethane	0.51	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodiiodomethane	0.56	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iodoform	0.54	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	0.06	ND		ND		ND	ND		ND	
Tribromochloromethane	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Haloacetic acids										
Monochloroacetic acid[d]	2		ND	ND	2.0	ND	2.8		ND	
Monobromoacetic acid[d]	1		ND	ND	1.2	ND	1.2		ND	
Dichloroacetic acid[d]	1		10	14	17	16	22		18	
Bromochloroacetic acid[d]	1		1.8	3.2	4.5	4.3	7.1		4.1	
Dibromoacetic acid[d]	1		ND	ND	ND	ND	1.0		ND	
Trichloroacetic acid[d]	1		ND	2.4	4.7	3.8	5.7		3.1	
Bromodichloroacetic acid	1		ND	ND	1.5	1.3	2.0		ND	
Dibromochloroacetic acid	1		ND	ND	ND	ND	ND		ND	
Tribromoacetic acid	2		ND	ND	ND	ND	ND		ND	
HAA5[i]			10	16	25	20	33		21	
HAA9[j]			12	20	31	25	42		25	
DXAA[k]			12	17	22	20	30		22	
TXAA[l]			ND	2.4	6.2	5.1	7.7		3.1	
Haloacetonitriles										
Chloroacetonitrile	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoacetonitrile	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichloroacetonitrile[d]	0.10	ND	0.1	0.2	0.5	0.3	0.9	0.6	0.6	0.7
Bromochloroacetonitrile[d]	0.1	ND	ND	0.1	0.2	0.1	0.3	0.3	0.2	0.2
Dibromoacetonitrile[d]	0.17	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroacetonitrile[d]	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Haloacetaldehydes										
Dichloroacetaldehyde	0.16	ND	0.3	0.5	1	0.8	1	1	1	2
Bromochloroacetaldehyde	0.1	<0.1	0.2	0.3	0.3	0.4	0.5	0.8	0.5	0.5
Chloral hydrate[d]	0.1	<0.1	0.1	0.4	0.5	0.4	1	0.5	0.6	0.6
Tribromoacetaldehyde	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table 16 (continued)

2/26/2001	MRL[a]	Plant 6[n]								
Compound	µg/L	Raw	Settled	Filter Eff	Clearwell Eff	Plant Eff	DS/Ave	DS/Max	SDS/Ave	SDS/Max
Haloketones										
Chloropropanone	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropanone[d]	0.11	ND	0.4	0.6	1	0.9	2	1	1	1
1,3-Dichloropropanone	0.10	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dibromopropanone	3	ND		ND		ND	ND		ND	
1,3-Dibromopropanone	3	ND		ND		ND	ND		ND	
1,1,1-Trichloropropanone[d]	0.10	ND	ND	0.3	0.6	0.4	0.8	0.3	0.4	0.4
1,1,3-Trichloropropanone	0.11	ND	ND	ND	ND	ND	0.2	ND	ND	ND
1-Bromo-1,1-dichloropropanone	3	ND		<1[h]		<1	<1		<1	
1,1,1-Tribromopropanone	3	ND		ND		ND	ND		ND	
1,1,3-Tribromopropanone	3	ND		ND		ND	ND		ND	
1,1,3,3-Tetrachloropropanone	0.12	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1,3-Tetrachloropropanone	3	ND		<1		<1	<1		<1	
1,1,3,3-Tetrabromopropanone	0.12	ND	ND	ND	ND	ND	ND	ND	ND	ND
Halonitromethanes										
Bromonitromethane	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichloronitromethane	3	ND		ND		ND	ND		ND	
Bromochloronitromethane	3	ND		ND		ND	ND		ND	
Dibromonitromethane	0.12	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloropicrin[d]	0.1	ND	ND	0.1	0.3	0.1	0.4	0.4	0.4	0.5
Miscellaneous Compounds										
Methyl ethyl ketone	1.90	ND		ND		ND	ND		ND	
Methyl *tertiary* butyl ether	0.16	ND		ND		ND	ND		ND	
Benzyl chloride	2	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table 17. Occurrence of other DBPs[a] at plants 5 and 6

Compound	Plant 6 (2/26/01)		Plant 5 (10/22/01)	
	ClO_2	$ClO_2 + Cl_2/NH_2Cl$	O_3	$O_3 + Cl_2$
Halomethanes				
Bromodichloromethane[b]	x	x	x	x
Dibromochloromethane	x	x	x	x
Bromoform	x	x	x	x
Dichloroiodomethane	x	x	-	x
Bromochloroiodomethane	x	x	-	-
Haloacids				
Chloroacetic acid	x	x	-	-
Dichloroacetic acid	x	x	x	x
Bromochloroacetic acid	x	x	-	-
Dibromoacetic acid	x	x	-	-
Bromodichloroacetic acid	-	x	-	-
Trichloroacetic acid	x	x	-	-
3,3-Dichloropropenoic acid	x	x	-	-
Trichloropropenoic acid	x	x	-	-
3,4,4-Trichloro-3-butenoic acid	-	-	-	x
Haloacetonitriles				
Dichloroacetonitrile	x	x	x	x
Bromochloroacetonitrile	x	x	-	x
Dibromoacetonitrile	x	x	-	x
Tribromoacetonitrile	x	x	-	-
Haloaldehydes				
Dichloroacetaldehyde	x	x	-	-
Trichloroacetaldehyde	x	x	x	x
2-Bromo-2-methylpropanal	x	x	x	x
*Iodobutanal	x	x	-	-
Haloketones				
Chloropropanone	x	x	-	-
1,1-Dichloropropanone	x	x	x	x
1-Bromo-1-chloropropanone	x	x	-	-
1,1,1-Trichloropropanone	x	x	x	x
1-Bromo-1,1-dichloropropanone	-	x	-	x
1,1,3,3-Tetrachloropropanone	x	x	-	-
1,1,1,3-Tetrachloropropanone	-	x	-	-
1-Bromo-1,3,3-trichloropropanone	x	x	-	-
1,1-Dibromo-3,3-dichloropropanone	x	x	-	-
Pentachloropropanone	-	x	-	x
Halonitromethanes				
Trichloronitromethane	-	x	-	X
Miscellaneous Halogenated DBPs				
Hexachlorocyclopentadiene	-	x	-	-
Dichloroacetic acid methyl ester	x	x	-	-
Non-halogenated DBPs				
Glyoxal	-	-	x	x
Methyl glyoxal	-	-	x	x
Hexanoic acid	x	-	-	-
Decanoic acid	x	x	-	-
Hexadecanoic acid	-	x	-	-

[a]DBPs detected by broadscreen gas chromatography/mass spectrometry (GC/MS) technique
[b]Compounds listed in italics were confirmed through the analysis of authentic standards; haloacids and non-halogenated carboxylic acids identified as their methyl esters.

Table 18. DBP results at plant 5 (8/13/01)

8/13/2001	MRL[a]	Plant 5[b]							
Compound	µg/L	Raw	GAC/Sand	GAC Inf	Plant Eff	DS/Ave	DS/Max	SDS/Ave	SDS/Max
Halomethanes									
Chloromethane	0.2	ND[c]			ND	ND		ND	
Bromomethane	0.2	ND			ND	ND		ND	
Bromochloromethane	0.5	ND			ND	ND		ND	
Dibromomethane	0.5	ND			ND	ND		ND	
Chloroform[d]	0.1	ND	ND	ND	9	15	20	12	25
Bromodichloromethane[d]	0.1	ND	ND	ND	11	15	17	11	18
Dibromochloromethane[d]	0.1	ND	ND	ND	5	6	6	5	6
Bromoform[d]	0.11	ND	ND	ND	0.5	0.6	0.7	0.4	0.5
THM4[f]		ND	ND	ND	26	37	44	28	50
Dichloroiodomethane	0.5	ND	ND	ND	ND	ND	ND	ND	ND
Bromochloroiodomethane	0.5	ND	ND	ND	ND	ND	ND	ND	ND
Dibromoiodomethane	0.52	ND	ND	ND	ND	ND	ND	ND	ND
Chlorodiiodomethane	0.1	ND	ND	ND	ND	ND	ND	ND	ND
Bromodiiodomethane	0.5	ND	ND	ND	ND	ND	ND	ND	ND
Iodoform	0.1	ND	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	0.2	ND			ND	ND		ND	
Tribromochloromethane	0.5	ND	ND	ND	ND	ND	ND	ND	ND
Haloacetic acids									
Monochloroacetic acid[d]	2				ND	2.5		7.1	
Monobromoacetic acid[d]	1				ND	ND		1.2	
Dichloroacetic acid[d]	1				18	21		40	
Bromochloroacetic acid[d]	1				11	12		14	
Dibromoacetic acid[d]	1				4.2	4.2		4.4	
Trichloroacetic acid[d]	1				12	16		18	
Bromodichloroacetic acid	1				7.9	8.6		1.1	
Dibromochloroacetic acid	1				2.6	2.8		2.0	
Tribromoacetic acid	2				ND	ND		ND	
HAA5[i]					34	44		71	
HAA9[j]					56	67		88	
DXAA[k]					33	37		58	
TXAA[l]					23	27		21	
Haloacetonitriles									
Chloroacetonitrile	0.1	ND	ND	ND	0.2	0.2	0.2	0.3	0.3
Bromoacetonitrile	0.1	ND	ND	ND	ND	ND	ND	ND	ND
Dichloroacetonitrile[d]	0.10	ND	ND	ND	2	2	2	3	5
Bromochloroacetonitrile[d]	0.1	ND	ND	ND	1	1	1	1	0.8
Dibromoacetonitrile[d]	0.14	ND	ND	ND	0.8	0.9	0.7	0.3	0.2
Trichloroacetonitrile[d]	0.1	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloroacetonitrile	0.5	ND			ND	ND			ND
Dibromochloroacetonitrile	0.5	ND			ND	ND			ND
Tribromoacetonitrile	0.5	ND			ND	ND			ND
Haloacetaldehydes									
Dichloroacetaldehyde	0.1	*2*[o]	*0.4*[o]	*ND*	*0.8*[o]	*1*[o]	*0.8*[o]	*4*[o]	*1*[o]
Bromochloroacetaldehyde	0.5	*1*[o]	*ND*	*ND*	*ND*	*ND*	*ND*	2	ND
Chloral hydrate[d]	0.1	*2*[o]	*0.1*[o]	ND	*11*[o]	*15*[o]	*18*[o]	*17*[o]	*26*[o]
Tribromoacetaldehyde	0.1	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	ND	ND

[o]Quality control problems with haloacetaldehydes

Table 18 (continued)

8/13/2001	MRL[a]	Plant 5[b]							
Compound	µg/L	Raw	GAC/Sand	GAC Inf	Plant Eff	DS/Ave	DS/Max	SDS/Ave	SDS/Max
Haloketones									
Chloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropanone[d]	0.10	ND	ND	ND	0.6	0.5	0.2	0.3	0.2
1,3-Dichloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dibromopropanone	0.10	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloropropanone[d]	0.1	ND	ND	ND	5	5	2	6	5
1,1,3-Trichloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND
1-Bromo-1,1-dichloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Tribromopropanone	0.29	ND	ND	ND	ND	ND	ND	ND	NR[e]
1,1,3-Tribromopropanone	0.14	ND	ND	ND	ND	ND	ND	ND	NR
1,1,3,3-Tetrachloropropanone	0.5	ND			ND	ND		ND	
1,1,1,3-Tetrachloropropanone	0.10	ND	ND	ND	ND	ND	ND	ND	ND
1,1,3,3-Tetrabromopropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND
Halonitromethanes									
Bromonitromethane	0.1	ND	ND	ND	ND	ND	ND	ND	ND
Dichloronitromethane	0.1	ND	ND	ND	0.7	0.9	0.8	0.1	0.5
Bromochloronitromethane	0.1	ND	ND	ND	0.2	0.2	0.2	ND	0.1
Dibromonitromethane	0.10	ND	ND	ND	ND	0.1	ND	ND	ND
Chloropicrin[d]	0.1	ND	ND	ND	0.4	0.6	0.7	0.6	1
Bromodichloronitromethane	0.5	ND			0.8	1			ND
Dibromochloronitromethane	0.5	ND			0.8	0.7			0.8
Bromopicrin	2.0	ND			ND	ND			ND
Miscellaneous Compounds									
Methyl ethyl ketone	0.5	7			2	1		3	
Methyl *tertiary* butyl ether	0.2	0.4			0.3	0.4		1	
1,1,2,2-Tetrabromo-2-chloroethane	0.1	ND	ND	ND	ND	ND	ND	ND	ND
Benzyl chloride	0.25	ND	NR	NR	ND	ND	NR	ND	NR

Table 19. DBP results at plant 6 (8/13/01)

8/13/2001	MRL[a]	Plant 6[n]								
Compound	µg/L	Raw	Settled	Filt Eff	Clearwell	Plant Eff	DS/Ave	DS/Max	SDS/Ave	SDS/Max
Halomethanes										
Chloromethane	0.2	ND[c]		ND		ND	ND		ND	
Bromomethane	0.2	ND		ND		ND	ND		ND	
Bromochloromethane	0.5	ND		ND		ND	ND		ND	
Dibromomethane	0.5	ND		ND		ND	ND		ND	
Chloroform[d]	0.1	ND	0.2	10	18	17	14	9	NR[e]	18
Bromodichloromethane[d]	0.1	ND	0.1	5	8	8	8	8	6	11
Dibromochloromethane[d]	0.1	ND	ND	0.9	2	1	2	2	1	2
Bromoform[d]	0.11	ND	ND	ND	ND	ND	ND	0.1	ND	0.1
THM4[f]	0	ND	0.3	16	28	26	24	19	NR	31
Dichloroiodomethane	0.5	ND	ND	0.8	0.5	0.9	0.5	ND	0.5	ND
Bromochloroiodomethane	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromoiodomethane	0.52	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorodiiodomethane	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodiiodomethane	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iodoform	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	0.2	ND		ND		ND	ND		ND	
Tribromochloromethane	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Haloacetic acids										
Monochloroacetic acid[d]	2		ND	ND	6.3	6.2	5.3		4.5	
Monobromoacetic acid[d]	1		ND	3.7	ND	ND	3.5		ND	
Dichloroacetic acid[d]	1		4.8	29	38	40	40		48	
Bromochloroacetic acid[d]	1		1.2	8.2	11	11	12		14	
Dibromoacetic acid[d]	1		ND	ND	1.2	ND	1.7		1.9	
Trichloroacetic acid[d]	1		ND	20	21	22	19		25	
Bromodichloroacetic acid	1		ND	7.5	7.9	8.0	8.1		10	
Dibromochloroacetic acid	1		ND	ND	1.5	1.2	1.3		1.5	
Tribromoacetic acid	2		ND	ND	ND	ND	ND		ND	
HAA5[i]			5	53	67	68	70		79	
HAA9[j]			6	68	87	88	91		105	
DXAA[k]			6	37	50	51	54		64	
TXAA[l]			ND	28	35	31	28		37	
Haloacetonitriles										
Chloroacetonitrile	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoacetonitrile	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichloroacetonitrile[d]	0.10	ND	0.2	2	2	2	2	2	3	3
Bromochloroacetonitrile[d]	0.1	ND	ND	0.3	0.5	0.5	0.6	0.7	0.4	0.7
Dibromoacetonitrile[d]	0.14	ND	ND	ND	ND	ND	0.2	0.2	0.1	0.1
Trichloroacetonitrile[d]	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloroacetonitrile	0.5	ND		ND		ND				ND
Dibromochloroacetonitrile	0.5	ND		ND		ND				ND
Tribromoacetonitrile	0.5	ND		ND		ND				ND
Haloacetaldehydes										
Dichloroacetaldehyde	0.1	*2*[o]	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*6*[o]	*3*[o]
Bromochloroacetaldehyde	0.5	*0.7*[o]	*ND*	*0.8*[o]	*ND*	*ND*	*ND*	*ND*	2	0.6
Chloral hydrate[d]	0.1	*1*[o]	*ND*	*3*[o]	*4*[o]	*4*[o]	*4*[o]	*3*[o]	*10*[o]	*6*[o]
Tribromoacetaldehyde	0.1	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	ND	ND

[o]Quality control problems with haloacetaldehydes

Table 19 (continued)

8/13/2001	MRL[a]	Plant 6[n]								
Compound	µg/L	Raw	Settled	Filt Eff	Clearwell	Plant Eff	DS/Ave	DS/Max	SDS/Ave	SDS/Max
Haloketones										
Chloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropanone[d]	0.10	ND	0.7	1	0.7	0.9	2	1	2	2
1,3-Dichloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dibromopropanone	0.10	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloropropanone[d]	0.1	ND	ND	2	2	2	1	0.3	0.5	0.3
1,1,3-Trichloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-Bromo-1,1-dichloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Tribromopropanone	0.29	ND	ND	ND	ND	ND	ND	ND	ND	NR
1,1,3-Tribromopropanone	0.14	ND	ND	ND	ND	ND	ND	ND	ND	NR
1,1,3,3-Tetrachloropropanone	0.5	ND		ND		ND	ND		ND	
1,1,1,3-Tetrachloropropanone	0.10	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,3,3-Tetrabromopropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Halonitromethanes										
Bromonitromethane	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichloronitromethane	0.1	ND	ND	ND	ND	0.1	ND	ND	0.1	0.1
Bromochloronitromethane	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromonitromethane	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloropicrin[d]	0.1	ND	ND	0.1	0.2	0.2	0.3	0.3	0.3	0.9
Bromodichloronitromethane	0.5	ND		ND		ND				ND
Dibromochloronitromethane	0.5	ND		ND		ND				ND
Bromopicrin	2.0	ND		ND		ND				ND
Miscellaneous Compounds										
Methyl ethyl ketone	0.5	3		4		2	1		0.5	
Methyl *tertiary* butyl ether	0.2	0.3		0.3		0.5	ND		0.5	
1,1,2,2-Tetrabromo-2-chloroethane	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzyl chloride	0.25	ND	NR	ND	NR	ND	ND	NR	ND	NR

Table 20. Additional target DBP results (µg/L) at plants 5 and 6 (8/13/01)

8/13/2001	Plant 5[a]						Plant 6					
Compound	Raw	OE1	GAC FE	PE	DS/ave	SDS/max	Raw	Settled	FE	PE	DS/ave	SDS/max
Monochloroacetaldehyde	0	0	0	0.1	0.2	0.3	0	0.3	0.2	0.1	0.1	0.1
Dichloroacetaldehyde	0	0	0	2.1	1.8	5.1	0	0.5	2.5	3.5	2.8	4.2
Bromochloroacetaldehyde	0	0	0	0.8	1.1	1.5	0	0	0.4	0.6	1.0	1.2
3,3-Dichloropropenoic acid	0	0	0	0	0	4.4	0	0	2.5	4.7	4.8	5.5
Bromochloromethylacetate	0	0	0	0	0	0	0	0	0	0	0	0
2,2-Dichloroacetamide	0	0	0	0	0	0	0	0	0	5.6	4.1	3.9
TOX (µg/L as Cl^-)	10.5		11.5	284	257	327	12.7	52.9	203	245	238	241
Cyanoformaldehyde	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		<0.1	<0.1	<0.1	<0.1
5-Keto-1-hexanal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
6-Hydroxy-2-hexanone	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dimethyglyoxal	<0.4	2.4	0.8	1.8	1.2	1.9	<0.4	1.6	0.5	1.2	1.4	1.6
trans -2-Hexenal	<0.1		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

[a]GAC FE = GAC filter effluent

Table 21. Halogenated furanone results (µg/L) at plants 5 and 6 (8/13/01)

8/13/2001	Plant 5			Plant 6				
Compound	GAC FE	PE	DS/ave	Raw	Settled	FE	PE	DS/ave
MX	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.31	0.30
ZMX	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
EMX	<0.04	<0.04	<0.04	<0.04	<0.04	0.23	<0.04	0.12
Mucochloric acid (ring)	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Mucochloric acid (open)	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04

Table 22. DBP results at plant 5 (10/22/01)

10/22/2001	MRL[a]	Plant 5[b]							
Compound	µg/L	Raw	GAC/Sand	GAC Inf	Plant Eff	DS/Ave	DS/Max	SDS/Ave	SDS/Max
Halomethanes									
Chloromethane	0.2	ND[c]			ND	ND		ND	
Bromomethane	0.2	ND			ND	ND		ND	
Bromochloromethane	0.5	ND			ND	ND		ND	
Dibromomethane	0.5	ND			ND	ND		ND	
Chloroform[d]	0.5	ND	ND	ND	10	34	NR[e]	58	60
Bromodichloromethane[d]	0.1	ND	ND	ND	19	31	NR	30	30
Dibromochloromethane[d]	0.1	ND	ND	ND	12	19	20	14	12
Bromoform[d]	0.1	ND	ND	ND	2	2	1	2	2
THM4[f]		ND	ND	ND	43	86	NR	104	104
Dichloroiodomethane	0.5	ND	ND	ND	0.5	<0.5[p]	NR	ND	ND
Bromochloroiodomethane	0.5	ND	NR	NR	ND	ND	NR	ND	NR
Dibromoiodomethane	0.52	ND	ND	ND	ND	ND	ND	ND	ND
Chlorodiiodomethane	0.1-0.5[q]	ND	ND	ND	ND	ND	ND	ND	ND
Bromodiiodomethane	0.5	ND	ND	ND	ND	ND	ND	ND	ND
Iodoform	1.0	ND	NR	NR	ND	ND	NR	ND	NR
Carbon tetrachloride	0.2	ND			ND	ND		ND	
Tribromochloromethane	0.5	ND	ND	ND	ND	ND	ND	ND	ND
Haloacetic acids									
Monochloroacetic acid[d]	2				ND	ND		4.1	
Monobromoacetic acid[d]	1				ND	ND		1.2	
Dichloroacetic acid[d]	1				4.5	5.9		28	
Bromochloroacetic acid[d]	1				4.2	4.9		19	
Dibromoacetic acid[d]	1				2.5	2.1		5.2	
Trichloroacetic acid[d]	1				2.7	6.4		9.4	
Bromodichloroacetic acid	1				3.8	6.2		8.3	
Dibromochloroacetic acid	1				2.0	2.5		3.0	
Tribromoacetic acid	2				ND	ND		ND	
HAA5[i]					10	14		48	
HAA9[j]					20	28		78	
DXAA[k]					11	13		52	
TXAA[l]					8.5	15		21	
Haloacetonitriles									
Chloroacetonitrile	0.1	ND	ND	ND	0.2	0.4	ND	0.4	0.5
Bromoacetonitrile	0.1	ND	ND	ND	ND	ND	ND	ND	ND
Dichloroacetonitrile[d]	0.1	ND	ND	ND	1	4	4	2	3
Bromochloroacetonitrile[d]	0.1	ND	ND	ND	1	2	2	2	1
Dibromoacetonitrile[d]	0.1	0.2	ND	ND	0.9	1	0.7	1	0.6
Trichloroacetonitrile[d]	0.1	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloroacetonitrile	0.5	ND			ND	ND			ND
Dibromochloroacetonitrile	0.5	ND			ND	ND			ND
Tribromoacetonitrile	0.9	ND			ND	ND			ND
Haloacetaldehydes									
Dichloroacetaldehyde	1.1	0.4	ND	0.2	1	2	2	4	3
Bromochloroacetaldehyde	0.5	ND	ND	0.1	0.5	0.2	1	ND	ND
Chloral hydrate[d]	0.1	1	ND	0.4	3	8	8	13	22
Tribromoacetaldehyde	0.1	ND	ND	0.6	ND	ND	ND	ND	ND

Table 22 (continued)

10/22/2001	MRL[a]	Plant 5[b]							
Compound	µg/L	Raw	GAC/Sand	GAC Inf	Plant Eff	DS/Ave	DS/Max	SDS/Ave	SDS/Max
Haloketones									
Chloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropanone[d]	0.10	ND	ND	ND	0.7	0.8	0.7	0.5	0.2
1,3-Dichloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dibromopropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloropropanone[d]	0.1	ND	ND	ND	4	5	4	4	3
1,1,3-Trichloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND
1-Bromo-1,1-dichloropropanone	0.1	ND	ND	ND	0.4	ND	ND	ND	ND
1,1,1-Tribromopropanone	0.1-0.3[q]	ND	ND	0.1	ND	ND	ND	ND	ND
1,1,3-Tribromopropanone	0.1-0.7[q]	ND	ND	0.1	ND	ND	ND	ND	ND
1,1,3,3-Tetrachloropropanone	2.5	ND	ND	ND	ND	ND	ND	ND	NR
1,1,1,3-Tetrachloropropanone	0.10	ND	ND	0.2	0.1	ND	ND	ND	ND
1,1,3,3-Tetrabromopropanone	0.5-2[q]	ND	ND	ND	ND	ND	ND	ND	ND
Halonitromethanes									
Bromonitromethane	0.1	ND	ND	ND	ND	ND	ND	0.1	0.5
Dichloronitromethane	0.1	ND	ND	ND	0.3	1	1	2	2
Bromochloronitromethane	0.1	ND	ND	ND	0.4	0.5	0.5	0.3	0.2
Dibromonitromethane	0.10	ND	ND	ND	0.6	0.5	0.4	0.2	0.1
Chloropicrin[d]	0.1	ND	ND	ND	0.3	2	2	1	NR
Bromodichloronitromethane	0.5	ND			ND	ND			1
Dibromochloronitromethane	0.5-2[r]	ND			ND	ND			1
Bromopicrin	0.5	ND			2	2			ND
Miscellaneous Compounds									
Methyl ethyl ketone	0.5	0.6			ND	ND		ND	
Methyl *tertiary* butyl ether	0.2	ND			ND	ND		ND	
1,1,2,2-Tetrabromo-2-chloroethane	0.5-2[q]	ND	ND	ND	ND	ND	ND	ND	ND
Benzyl chloride	0.25	ND	NR	NR	ND	ND	NR	ND	NR

[p]<0.5 = Detected by GC/MS below its MRL of 0.5 µg/L;
quality assurance problem with gas chromatograph method

[q]Higher MRL for SDS samples

[r]Lower MRL for SDS samples

Table 23. DBP results at plant 6 (10/22/01)

10/22/2001	MRL[a]	Plant 6[n]								
Compound	µg/L	Raw	Settled	Filt Eff	Clearwell	Plant Eff	DS/Ave	DS/Max	SDS/Ave	SDS/Max
Halomethanes										
Chloromethane	0.2	ND[c]		ND		ND	ND		ND	
Bromomethane	0.2	ND		ND		ND	ND		ND	
Bromochloromethane	0.5	ND		ND		ND	ND		ND	
Dibromomethane	0.5	ND		ND		ND	ND		ND	
Chloroform[d]	0.5	0.5	0.6	13	NR[e]	18	24	NR	17	22
Bromodichloromethane[d]	0.1	0.1	0.2	12	NR	21	24	NR	19	26
Dibromochloromethane[d]	0.1	ND	ND	4	6	7	8	NR	8	6
Bromoform[d]	0.1	ND	ND	0.4	0.5	0.5	0.5	0.5	0.6	0.8
THM4[f]		0.6	0.8	29	NR	47	57	NR	45	55
Dichloroiodomethane	0.5	ND	0.5	3	2	3	4	NR	3	2
Bromochloroiodomethane	0.5	ND	NR	ND	NR	<0.5[p]	<0.5	NR	<0.5	NR
Dibromoiodomethane	0.52	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorodiiodomethane	0.1-0.5[q]	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodiiodomethane	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iodoform	1.0	ND	NR	ND	NR	ND	ND	NR	ND	NR
Carbon tetrachloride	0.2	ND		ND		ND	ND		ND	
Tribromochloromethane	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Haloacetic acids										
Monochloroacetic acid[d]	2		ND	ND	2.4	2.2	2.6		3.0	
Monobromoacetic acid[d]	1		ND	ND	ND	ND	ND		ND	
Dichloroacetic acid[d]	1		2.8	9.7	13	12	14		23	
Bromochloroacetic acid[d]	1		1.3	4.7	6.6	6.3	7.2		11	
Dibromoacetic acid[d]	1		ND	1.6	2.2	2.0	2.2		3.1	
Trichloroacetic acid[d]	1		ND	4.6	7.4	6.5	6.9		10	
Bromodichloroacetic acid	1		ND	3.7	4.8	4.5	4.5		6.2	
Dibromochloroacetic acid	1		ND	2.2	2.3	2.1	2.0		2.0	
Tribromoacetic acid	2		ND	ND	ND	ND	ND		ND	
HAA5[i]			2.8	16	25	23	26		39	
HAA9[j]			4.1	27	39	36	39		58	
DXAA[k]			4.1	16	22	20	23		37	
TXAA[l]			ND	11	15	13	13		18	
Haloacetonitriles										
Chloroacetonitrile	0.1	ND	ND	ND	ND	ND	0.4	ND	0.4	ND
Bromoacetonitrile	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichloroacetonitrile[d]	0.1	ND	0.1	1	2	2	3	NR	3	4
Bromochloroacetonitrile[d]	0.1	ND	ND	0.6	0.9	1	1	NR	1	2
Dibromoacetonitrile[d]	0.1	ND	ND	0.2	0.3	0.4	0.4	NR	0.4	0.7
Trichloroacetonitrile[d]	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloroacetonitrile	0.5	ND		ND		ND				ND
Dibromochloroacetonitrile	0.5	ND		ND		ND				0.5
Tribromoacetonitrile	0.9	ND		ND		ND				ND
Haloacetaldehydes										
Dichloroacetaldehyde	1.1	0.4	ND	2	2	2	2	8	12	12
Bromochloroacetaldehyde	0.5	ND	ND	0.4	0.5	0.5	0.7	0.8	2	3
Chloral hydrate[d]	0.1	ND	ND	ND	3	2	3	2	6	6
Tribromoacetaldehyde	0.1	ND	ND	ND	ND	ND	ND	0.9	ND	1

Table 23 (continued)

10/22/2001	MRL[a]	Plant 6[n]								
Compound	µg/L	Raw	Settled	Filt Eff	Clearwell	Plant Eff	DS/Ave	DS/Max	SDS/Ave	SDS/Max
Haloketones										
Chloropropanone	0.1	ND	ND	ND	ND	ND	0.1	0.2	ND	ND
1,1-Dichloropropanone[d]	0.10	ND	ND	1	0.9	1	2	2	2	NR
1,3-Dichloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND	0.1
1,1-Dibromopropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloropropanone[d]	0.1	0.1	ND	2	2	2	2	NR	2	2
1,1,3-Trichloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-Bromo-1,1-dichloropropanone	0.1	ND	ND	0.4	0.5	0.4	ND	ND	ND	ND
1,1,1-Tribromopropanone	0.1-0.3[q]	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,3-Tribromopropanone	0.1-0.7[q]	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,3,3-Tetrachloropropanone	2.5	ND	ND	ND	ND	ND	ND	ND	ND	NR
1,1,1,3-Tetrachloropropanone	0.10	ND	ND	0.1	0.2	0.1	ND	0.4	ND	0.5
1,1,3,3-Tetrabromopropanone	0.5-2[q]	ND	ND	ND	ND	ND	ND	ND	ND	ND
Halonitromethanes										
Bromonitromethane	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichloronitromethane	0.1	ND	ND	ND	ND	ND	0.2	ND	0.2	0.3
Bromochloronitromethane	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromonitromethane	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloropicrin[d]	0.1	ND	ND	0.2	0.2	0.2	0.4	0.5	0.6	0.9
Bromodichloronitromethane	0.5	ND		ND		ND				0.8
Dibromochloronitromethane	0.5-2[r]	ND		ND		ND				0.5
Bromopicrin	0.5	ND		ND		ND				ND
Miscellaneous Compounds										
Methyl ethyl ketone	0.5	0.7		ND		ND	0.6		ND	
Methyl *tertiary* butyl ether	0.2	ND		ND		ND	ND		ND	
1,1,2,2-Tetrabromo-2-chloroethane	0.5-2[q]	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzyl chloride	0.25	ND	NR	ND	NR	ND	ND	NR	ND	NR

Table 24. DBP results at plant 5 (4/15/02)

4/15/2002	MRL[a]	Plant 5[b]							
Compound	µg/L	Raw	GAC/Sand	GAC Inf	Plant Eff	DS/Ave	DS/Max	SDS/Ave	SDS/Max
Halomethanes									
Chloromethane	0.2	ND[c]			ND	ND		ND	
Bromomethane	0.2	ND			ND	ND		ND	
Bromochloromethane	0.5	ND			ND	ND		ND	
Dibromomethane	0.5	ND			ND	ND		ND	
Chloroform[d]	0.2	ND	ND	ND	11	26	NR[e]	49	NR
Bromodichloromethane[d]	0.2	ND	ND	ND	14	17	NR	26	NR
Dibromochloromethane[d]	0.2	ND	ND	ND	7	8	NR	7	NR
Bromoform[d]	0.1	ND	ND	ND	0.9	0.9	0.7	1	1
THM4[f]		ND	ND	ND	33	52	NR	83	NR
Dichloroiodomethane	0.5	ND	ND	ND	ND	ND	ND	ND	ND
Bromochloroiodomethane	0.5	ND	NR	NR	ND	ND	NR	ND	NR
Dibromoiodomethane	0.5	ND	ND	ND	ND	ND	ND	ND	ND
Chlorodiiodomethane	0.1	ND	ND	ND	ND	ND	ND	ND	ND
Bromodiiodomethane	0.5	ND	ND	ND	ND	ND	ND	ND	ND
Iodoform	2	ND	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	0.2	ND			ND	ND		ND	
Tribromochloromethane	0.5	ND	NR	NR	ND	ND	NR	ND	NR
Haloacetic acids									
Monochloroacetic acid[d]	2				2.2	3.6		6.2	
Monobromoacetic acid[d]	1				ND	ND		1.1	
Dichloroacetic acid[d]	1				12	17		26	
Bromochloroacetic acid[d]	1				5.3	6.3		6.4	
Dibromoacetic acid[d]	1				1.9	1.9		2.4	
Trichloroacetic acid[d]	1				6.9	11		9.2	
Bromodichloroacetic acid	1				7.3	7.7		7.1	
Dibromochloroacetic acid	1				2.1	2.1		2.0	
Tribromoacetic acid	2				ND	ND		ND	
HAA5[i]					23	34		45	
HAA9[j]					38	50		60	
DXAA[k]					19	25		35	
TXAA[l]					16	21		18	
Haloacetonitriles									
Chloroacetonitrile	0.1	ND	ND	ND	0.4	0.3	0.5	0.8	0.6
Bromoacetonitrile	0.1	ND	ND	ND	ND	ND	ND	ND	ND
Dichloroacetonitrile[d]	0.1	ND	ND	ND	NR	1	NR	5	NR
Bromochloroacetonitrile[d]	0.1	ND	ND	ND	1	1	0.8	2	1
Dibromoacetonitrile[d]	0.1	ND	ND	ND	0.4	0.4	0.4	0.6	0.6
Trichloroacetonitrile[d]	0.5	ND	NR	NR	ND	ND	NR	ND	NR
Bromodichloroacetonitrile	0.5	ND			ND	ND			ND
Dibromochloroacetonitrile	0.5	ND			ND	ND			ND
Tribromoacetonitrile	0.96	ND			ND	ND			ND
Haloacetaldehydes									
Dichloroacetaldehyde	0.5	ND	ND	0.5	2	2	3	4	4
Bromochloroacetaldehyde	0.5	ND	ND	ND	0.5	ND	ND	0.7	0.6
Chloral hydrate[d]	0.1	ND	0.1	0.3	6	6	13	22	18
Tribromoacetaldehyde	0.1	ND	ND	0.3	ND	ND	ND	ND	ND

Table 24 (continued)

4/15/2002	MRL[a]	Plant 5[b]							
Compound	µg/L	Raw	GAC/Sand	GAC Inf	Plant Eff	DS/Ave	DS/Max	SDS/Ave	SDS/Max
Haloketones									
Chloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropanone[d]	1.0	ND	ND	ND	<1[s]	1	NR	ND	NR
1,3-Dichloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dibromopropanone	0.5	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloropropanone[d]	0.5	ND	ND	ND	4	8	NR	13	NR
1,1,3-Trichloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND
1-Bromo-1,1-dichloropropanone	0.3	ND	NR	NR	0.4	0.4	NR	ND	NR
1,1,1-Tribromopropanone	>5	ND	NR	NR	ND	ND	NR	ND	NR
1,1,3-Tribromopropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND
1,1,3,3-Tetrachloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1,3-Tetrachloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND
1,1,3,3-Tetrabromopropanone	0.5	ND	ND	ND	ND	ND	ND	ND	ND
Halonitromethanes									
Chloronitromethane	0.2	ND			0.6	2			
Bromonitromethane	0.1	ND	ND	ND	ND	ND	ND	ND	ND
Dichloronitromethane	0.1	ND	ND	ND	0.4	0.5	0.7	0.7	0.3
Bromochloronitromethane	0.1	ND	ND	ND	ND	ND	ND	0.3	ND
Dibromonitromethane	0.1	ND	ND	ND	ND	ND	ND	ND	ND
Chloropicrin[d]	0.1	ND	ND	ND	1	1	3	3	3
Bromodichloronitromethane	0.5	ND			ND	ND			ND
Dibromochloronitromethane	2	ND			ND	ND			ND
Bromopicrin	0.5	ND			ND	ND			ND
Miscellaneous Compounds									
Methyl ethyl ketone	0.5	0.7			0.8	0.7		0.7	
Methyl *tertiary* butyl ether	0.2	ND			ND	ND		ND	
1,1,2,2-Tetrabromo-2-chloroethane	0.5	ND	ND	ND	ND	ND	ND	ND	ND
Benzyl chloride	0.25	ND	NR	NR	ND	ND	NR	ND	NR

[s]<1 = Detected by GC/MS below its MRL of 1.0 µg/L;
quality assurance problem with gas chromatograph method

Table 25. DBP results at plant 6 (4/15/02)

4/15/2002	MRL[a]	Plant 6[n]								
Compound	µg/L	Raw	Settled	Filt Eff	Clearwell	Plant Eff	DS/Ave	DS/Max	SDS/Ave	SDS/Max
Halomethanes										
Chloromethane	0.2	ND[c]		ND		0.2	ND		ND	
Bromomethane	0.2	ND		ND		ND	ND		ND	
Bromochloromethane	0.5	ND		ND		ND	ND		ND	
Dibromomethane	0.5	ND		ND		ND	ND		ND	
Chloroform[d]	0.2	ND	ND	8	NR[e]	13	19	NR	13	18
Bromodichloromethane[d]	0.2	ND	0.4	6	NR	10	10	NR	11	10
Dibromochloromethane[d]	0.2	ND	ND	2	NR	3	2	NR	3	3
Bromoform[d]	0.1	ND	ND	0.4	0.4	0.4	0.2	ND	0.4	0.5
THM4[f]		ND	0.4	16	NR	26	31	NR	27	32
Dichloroiodomethane	0.5	ND	ND	1	NR	1	1	ND	0.7	0.5
Bromochloroiodomethane	0.5	ND	NR	<1[s]	NR	<1	<1	NR	<1	ND
Dibromoiodomethane	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorodiiodomethane	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodiiodomethane	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iodoform	2	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	0.2	ND		ND		ND	ND		ND	
Tribromochloromethane	0.5	ND	NR	ND	NR	ND	ND	NR	ND	ND
Haloacetic acids										
Monochloroacetic acid[d]	2	ND	ND	2.3	2.4	2.5	2.8		3.3	
Monobromoacetic acid[d]	1	ND	ND	ND	ND	ND	ND		ND	
Dichloroacetic acid[d]	1	ND	5.2	16	21	22	27		27	
Bromochloroacetic acid[d]	1	ND	ND	5.0	5.8	8.3	5.5		6.7	
Dibromoacetic acid[d]	1	ND	ND	ND	1.2	1.2	ND		1.6	
Trichloroacetic acid[d]	1	ND	ND	5.0	7.0	6.7	8.6		7.2	
Bromodichloroacetic acid	1	ND	ND	3.1	4.0	4.0	3.4		4.0	
Dibromochloroacetic acid	1	ND	ND	1.2	3.2	3.5	2.2		1.1	
Tribromoacetic acid	2	ND	ND	ND	ND	ND	ND		ND	
HAA5[i]		ND	5.2	23	32	32	38		39	
HAA9[j]		ND	5.2	33	45	48	50		51	
DXAA[k]		ND	5.2	21	28	32	33		35	
TXAA[l]		ND	ND	9.3	14	14	14		12	
Haloacetonitriles										
Chloroacetonitrile	0.1	ND	ND	ND	ND	0.1	0.2	ND	0.2	0.2
Bromoacetonitrile	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichloroacetonitrile[d]	0.1	ND	NR	0.7	NR	1	1	NR	4	2
Bromochloroacetonitrile[d]	0.1	ND	ND	0.4	ND	0.6	0.6	ND	0.9	1
Dibromoacetonitrile[d]	0.1	ND	ND	ND	0.2	0.1	<0.5[p]	ND	0.2	0.2
Trichloroacetonitrile[d]	0.5	ND	NR	ND	NR	ND	ND	NR	ND	ND
Bromodichloroacetonitrile	0.5	ND		ND		ND				ND
Dibromochloroacetonitrile	0.5	ND		ND		ND				ND
Tribromoacetonitrile	0.96	ND		ND		ND				ND
Haloacetaldehydes										
Dichloroacetaldehyde	0.5	ND	0.5	5	3	2	4	6	5	6
Bromochloroacetaldehyde	0.5	ND	ND	1	0.6	ND	ND	ND	0.7	0.8
Chloral hydrate[d]	0.1	1	0.2	2	3	2	4	4	4	4
Tribromoacetaldehyde	0.1	ND	ND	0.9	ND	ND	ND	ND	ND	ND

Table 25 (continued)

4/15/2002	MRL[a]	Plant 6[n]								
Compound	µg/L	Raw	Settled	Filt Eff	Clearwell	Plant Eff	DS/Ave	DS/Max	SDS/Ave	SDS/Max
Haloketones										
Chloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropanone[d]	1.0	ND	NR	2	NR	2	3	NR	2	3
1,3-Dichloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dibromopropanone	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloropropanone[d]	0.5	ND	ND	2	NR	2	2	NR	2	0.9
1,1,3-Trichloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-Bromo-1,1-dichloropropanone	0.3	ND	NR	0.6	NR	<1	ND	NR	ND	ND
1,1,1-Tribromopropanone	>5	ND	NR	ND	NR	ND	ND	NR	ND	NR
1,1,3-Tribromopropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,3,3-Tetrachloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1,3-Tetrachloropropanone	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,3,3-Tetrabromopropanone	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Halonitromethanes										
Chloronitromethane	0.2	ND		0.3		0.8				1
Bromonitromethane	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichloronitromethane	0.1	ND	ND	0.1	ND	0.1	0.1	ND	0.1	0.1
Bromochloronitromethane	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromonitromethane	0.1	ND	ND	0.1	ND	ND	ND	ND	ND	ND
Chloropicrin[d]	0.1	ND	ND	0.5	1	0.8	1	2	2	NR
Bromodichloronitromethane	0.5	ND		ND		ND				ND
Dibromochloronitromethane	2	ND		ND		ND				ND
Bromopicrin	0.5	ND		ND		ND				ND
Miscellaneous Compounds										
Methyl ethyl ketone	0.5	0.7		ND		ND	0.6		ND	
Methyl *tertiary* butyl ether	0.2	ND		ND		ND	ND		ND	
1,1,2,2-Tetrabromo-2-chloroethane	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzyl chloride	0.25	ND	NR	ND	NR	ND	ND	NR	ND	ND

Table 26. Additional target DBP results (µg/L) at plants 5 and 6 (4/15/02)

4/15/2002	Plant 5						Plant 6					
Compound	Raw	OE1	Comb FE	PE	DS/max	SDS/max	Raw	Settled	FE	PE	DS/max	SDS/max
Monochloroacetaldehyde	0	0	0	0.4	0.5	0.6	0	0.7	1.6	1.4	2.1	1.7
Dichloroacetaldehyde	0	0	0	2.0	2.0	2.8	0	1.0	2.3	2.8	4.9	3.9
Bromochloroacetaldehyde	0	0	0	0.4	0.4	0.6	0	0	0.5	0.5	0.4	0.7
3,3-Dichloropropenoic acid	0	0	0	0.7	0.2	0.4	0	0	0	0	0	0
Bromochloromethylacetate	0	0	0	0	0	0	0	0	0	0	0	0
Monochloroacetamide	0	0	0	0	0	0	0	0	0	0.2	0.8	0.3
Monobromoacetamide	0	0	0	0	0	0	0	0	0	0	0	0.1
2,2-Dichloroacetamide	0	0	0	0.5	0.2	0.5	0	0	0.8	2.7	7.6	9.4
Dibromoacetamide	0	0	0	0	0.1	0	0	0	0.1	0.2	0	0.2
Trichloroacetamide	0	0	0	0.3	0.1	0	0	0	0.2	1.1	2.2	4.1
TOX (µg/L as Cl^-)	26.0		54.4	177	259	247	29.7	90.2	154	210	243	
TOBr (µg/L as Br^-)	5.5		10.1	41.5	36.0	51.0	11.9	33.2	25.9		19.2	
TOCl (µg/L as Cl^-)	26.9		25.8	161	194	220	17.3	76.3	152		229	
Cyanoformaldehyde	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
5-Keto-1-hexanal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4
6-Hydroxy-2-hexanone	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dimethyglyoxal	<0.1	0.8	<0.1	0.4	0.2	0.3	<0.1	<0.1	0.5	<0.1	<0.1	<0.1
trans -2-Hexenal	<0.1	0.8	0.4	<0.1	<0.1	<0.1	<0.1	0.2	0.1	<0.1	<0.1	0.5

Table 27. Halogenated furanone results (µg/L) at plants 5 and 6 (4/15/02)

4/15/2002	Plant 5				Plant 6				
Compound	Comb FE	PE	DS/max	SDS/max	Raw	Settled	FE	PE	DS/max
BMX-1	<0.02	<0.02	<0.02 (0.012)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
BEMX-1	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.04	<0.02	<0.02
BMX-2	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
BEMX-2	<0.02	0.03	<0.02	<0.02	<0.02	<0.02	0.05	<0.02	0.11
BMX-3	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
BEMX-3	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
MX	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05	<0.02	0.09
Red-MX	<0.02	<0.02 (0.01)	<0.02	<0.02	<0.02	0.02	0.04	0.58	0.28
EMX	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
ZMX	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.23	<0.02
Ox-MX	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mucochloric acid (ring)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mucochloric acid (open)	0.02	0.31	0.40	<0.02	<0.02	0.02	0.08	0.08	0.11

Summary of tables for halogenated organic and other nonhalogenated organic DBPs

DBP Analyses (Laboratory)	11/27/00	2/26/01	8/13/01	10/22/01	4/15/02
Halogenated organic DBPs (MWDSC)	Tables 12-13	Tables 15-16	Tables 18-19	Tables 22-23	Tables 24-25
Additional target DBPs (UNC)	Table 14		Table 20		Table 26
Halogenated furanones (UNC)			Table 21		Table 27
Broadscreen analysis (USEPA)		Table 17[a]		Table 17[b]	

[a]Plant 6
[b]Plant 5

Halomethanes. For the five sample dates, pre-ozonation/post-chlorination at plant 5 resulted in the formation of 18-43 µg/L of the four regulated trihalomethanes (THM4) in the plant effluent samples. Chlorine dioxide/chlorine/chloramine disinfection at plant 6 resulted in the formation of 4-47 µg/L of THM4.

Figure 6 shows the effect of bromide on THM speciation in the distribution systems of both utilities. Because of the lower level of bromide in this source water in February 2001 (0.04-0.05 mg/L), the major THM species were chloroform and bromodichloromethane, whereas in November 2000 (bromide = 0.08 mg/L), there was a higher mixture of brominated species formed.

Figure 6

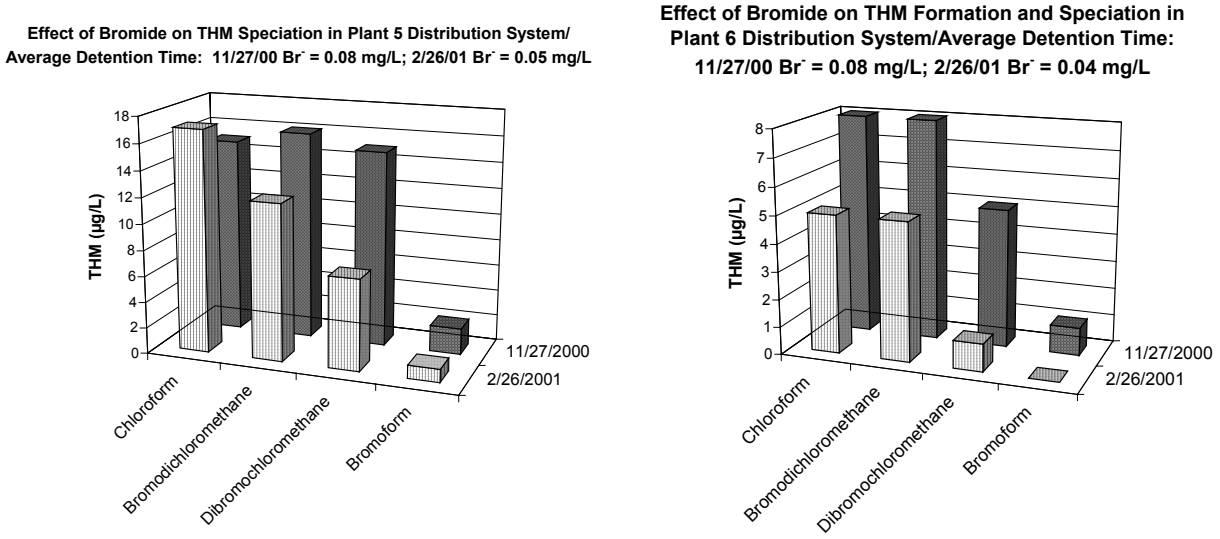
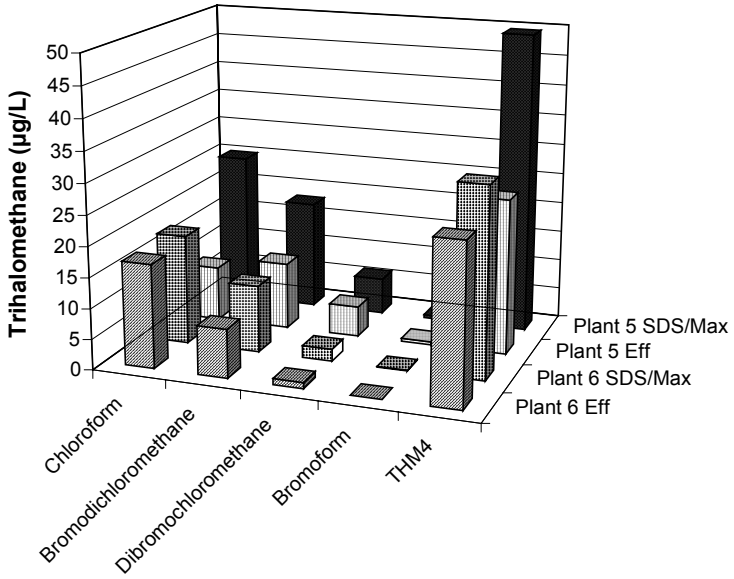


Figure 7 shows the impact of pre-ozonation/post-chlorination at plant 5 versus chlorine dioxide/chlorine/chloramine disinfection at plant 6 on THM formation and speciation for the August 13, 2001 sampling. On this date, both plant effluents had 26 µg/L THM4. At plant 6, the major THM formed was chloroform, whereas at plant 5 the major THM formed was bromodichloromethane. Although both plants treated water with a similar amount of bromide (0.05-0.06 mg/L), the amount of TOC at the point of chlorination was lower at plant 5 than at

Figure 7

Impact of Ozonation/Chlorination at Plant 5 versus Chlorine Dioxide/Chlorine/Chloramine Disinfection at Plant 6 on Trihalomethane Formation and Speciation (August 13, 2001)

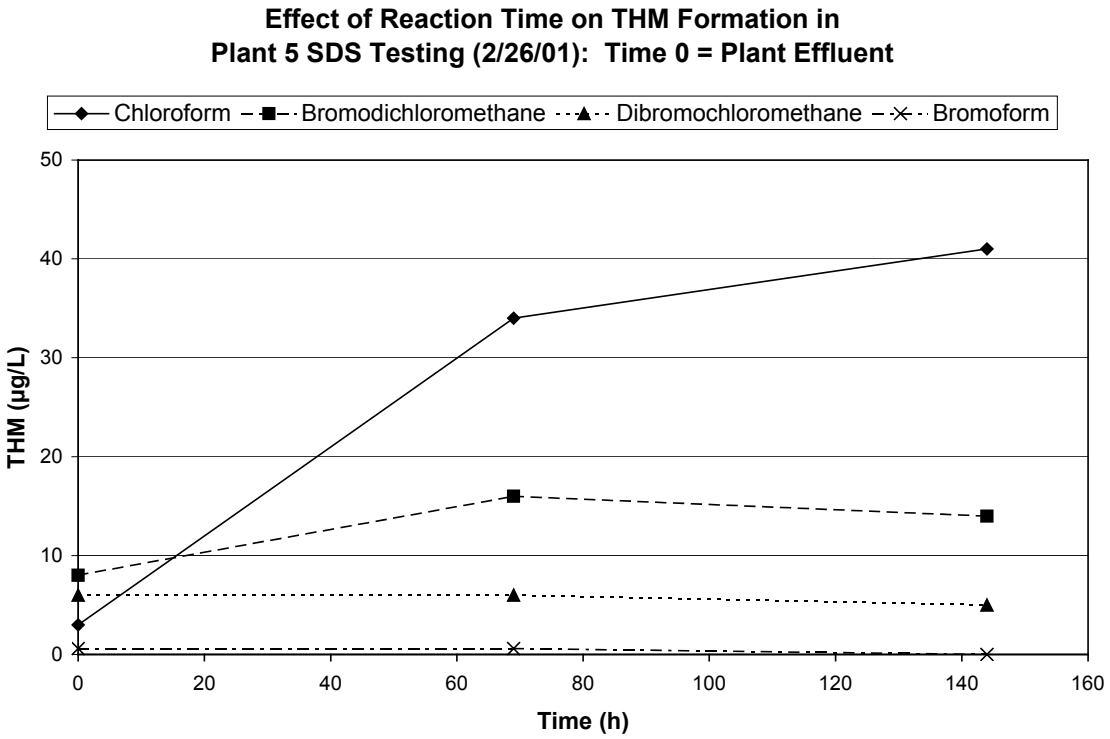


plant 6: 2.3-2.8 mg/L in the plant 5 filter effluent versus 4.5-4.7 mg/L in the plant 6 filter influent and effluent. At plant 5, the ozonation and biofiltration processes provided additional TOC reduction. As a result, the bromide-to-TOC ratio was higher at plant 5 than at plant 6. Other research has shown that a higher bromide-to-TOC ratio can result in a shift in speciation to the more brominated THMs (Symons et al., 1993). In addition, in some waters, pre-ozonation has been found to shift the THM formation to more brominated species (Jacanglo et al., 1989) because ozone converts some of the bromide to hypobromous acid.

Because plant 6 used chloramines in the distribution system, the THMs were found to not increase significantly in concentration in the SDS testing in August 2001 (Figure 7), where the SDS/maximum sample was held for seven days. Because plant 5 used free chlorine in the distribution system, the THMs were found to increase in concentration in the SDS testing in August 2001 (Figure 7), where the SDS/maximum sample was held for seven days. In this plant 5 SDS sample, the major THM was chloroform rather than bromodichloro-methane. The THM speciation at plant 5 is consistent with the difference in kinetics of halogenation between hypobromous acid and chlorine; that is, halogenation by hypobromous acid is quicker (Krasner et al., 1996). Thus, bromodichloromethane formed quicker than chloroform (plant effluent sample), whereas more of chloroform formed while the SDS sample was held for seven days.

Figure 8 shows more fully the effect of reaction time on THM formation in the SDS testing conducted on February 26, 2001. The concentration of chloroform increased over time,

Figure 8

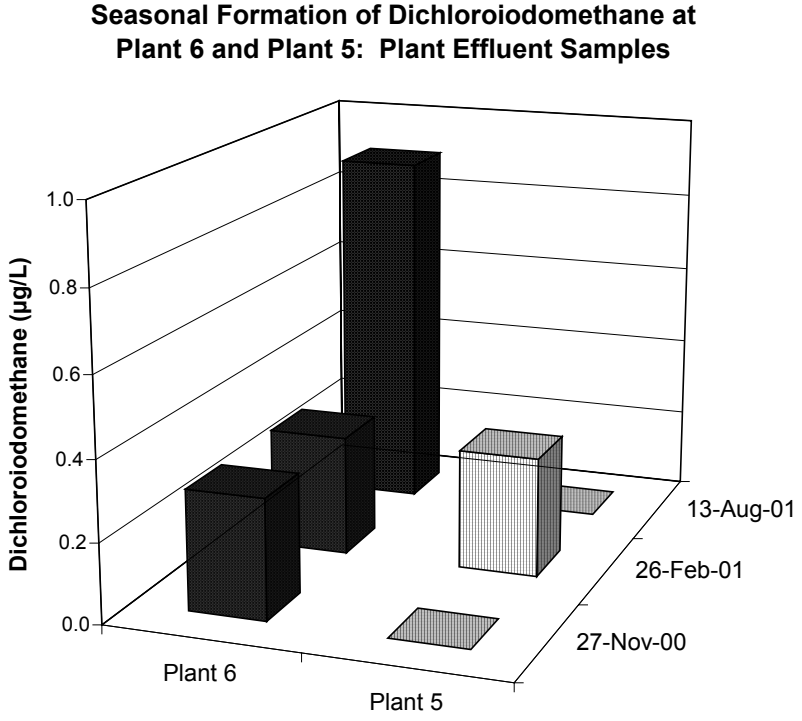


the formation of bromodichloromethane plateaued out during the SDS testing, and the amounts of the more brominated species were at their maximum values in the plant effluent. Again, this phenomenon was due to the fact that the kinetics of brominated DBP formation are faster than the kinetics of chlorinated DBP formation (Krasner et al., 1996).

In addition, low levels of certain iodinated THMs (e.g., dichloroiodomethane) were detected in selected samples, especially at plant 6 (Figure 9). In October 2001, 3 µg/L of dichloroiodomethane was detected in the plant 6 effluent, whereas 0.5 µg/L was detected in the plant 5 effluent. Bromochloroiodomethane was also detected in the plant 6 effluent in February 2001 using broadscreen GC/MS techniques (Table 17). Waters that contain bromide may also contain iodide. Iodide is oxidized to hypoiodous acid in the presence of ozone, chlorine, or chloramines (Bichsel and von Gunten, 2000). Hypoiodous acid can react with the TOC to form iodinated THMs. Bichsel and von Gunten (2000) found that ozone could also oxidize iodide to iodate and, depending on ozonation conditions, form little to no iodinated THMs; whereas chlorine lead to the formation of iodate and iodinated THMs. Although iodate was not measured in this study, the use of ozone at plant 5 did result in the formation of less iodinated THMs in the finished water than at plant 6.

Haloacids. Pre-ozonation/post-chlorination at plant 5 resulted in the formation of 10-34 µg/L of the five regulated haloacetic acids (HAA5) in the plant effluent samples, whereas chlorine dioxide/chlorine/chloramine disinfection at plant 6 resulted in the formation of 20-68

Figure 9



µg/L of HAA5. In addition, all nine HAAs (HAA9) were measured, which includes all of the brominated HAA species. The levels of HAA9 in the plant 5 effluent were 20-56 µg/L, whereas the levels of HAA9 in the plant 6 effluent were 25-88 µg/L.

Figure 10 shows the effect of bromide on HAA speciation in SDS testing at plant 5 (a similar effect was observed at plant 6). Because of the lower level of bromide in this water in February 2001, the two major HAAs were di- and trichloroacetic acid (DCAA and TCAA), whereas in November 2000 there was a higher mixture of brominated species formed.

Figure 11 shows the effect of the two disinfection schemes on the seasonal formation of THMs and HAAs in the plant effluents of plant 5 and plant 6. At plant 5, the sum of the dihalogenated HAAs (DXAAs) was somewhat higher than the sum of the trihalogenated HAAs (TXAAs) (Figure 11). This is consistent with the research of Reckhow and Singer (1984), in which ozonation was found to control the formation of TCAA better than that of DCAA.

At plant 6, in the settled water after chlorine dioxide disinfection, almost all of the HAAs that were formed were DXAAs; no TXAAs were detected (Figure 12). (In addition, the level of THMs was almost non-detectable at this sample location.) At this point in the treatment process, only chlorine dioxide disinfection had been utilized. In other DBP research, chlorine dioxide has been shown to produce little or no THMs and TXAAs, whereas DXAAs were formed (Zhang et al., 2000). After the addition of free chlorine at plant 6, the levels of HAAs increased, including the formation of TXAAs (Figure 12). However, DXAAs still predominated in the plant 6 samples (more so than at plant 5) (Figure 11).

Figure 10

Effect of Bromide on HAA Speciation in Plant 5 SDS Testing/
Average Detention Time: 11/27/00 Br^- = 0.08 mg/L; 2/26/01 Br^- = 0.05 mg/L

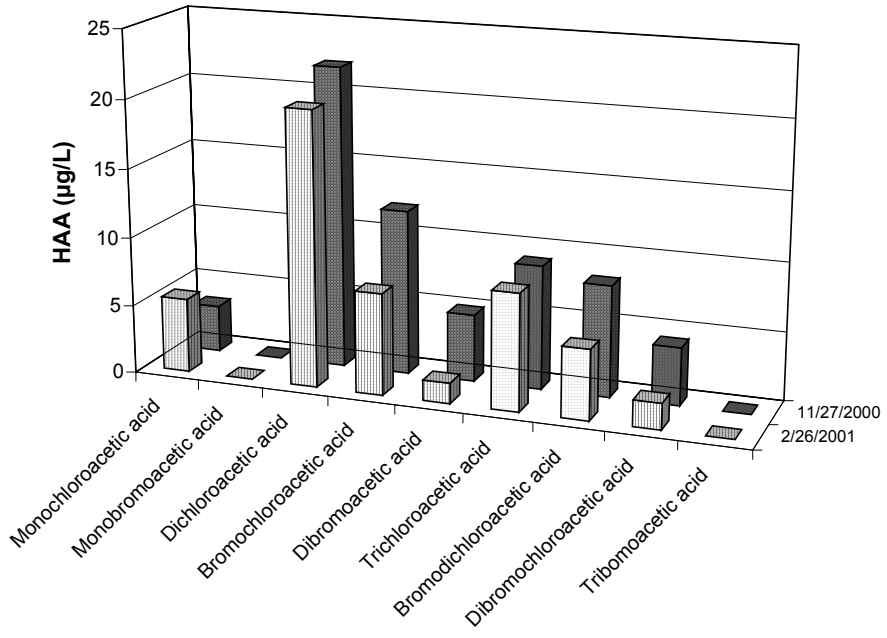


Figure 11

Seasonal Formation of Trihalomethanes and Haloacetic Acids
at Plant 5 and Plant 6: Plant Effluent Samples

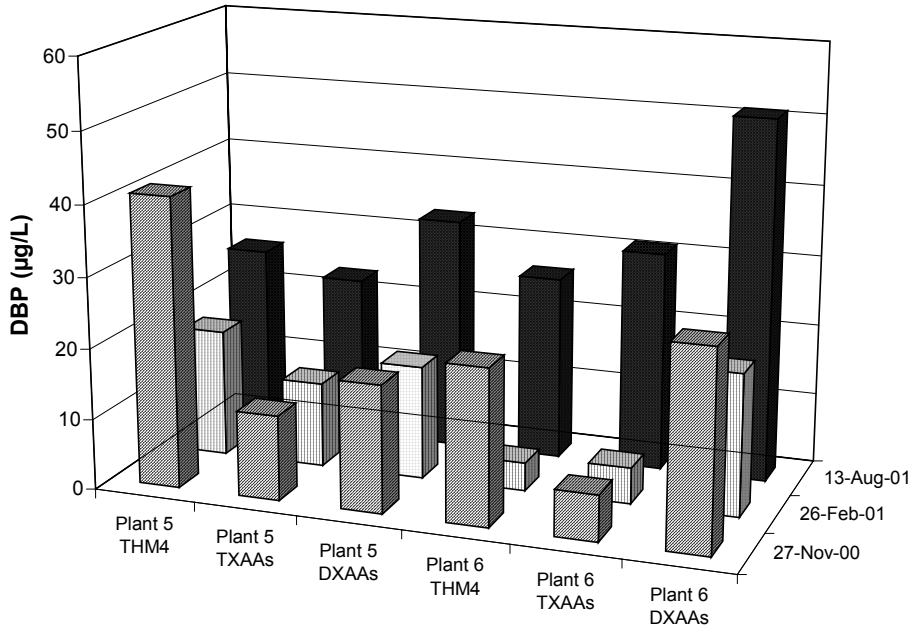
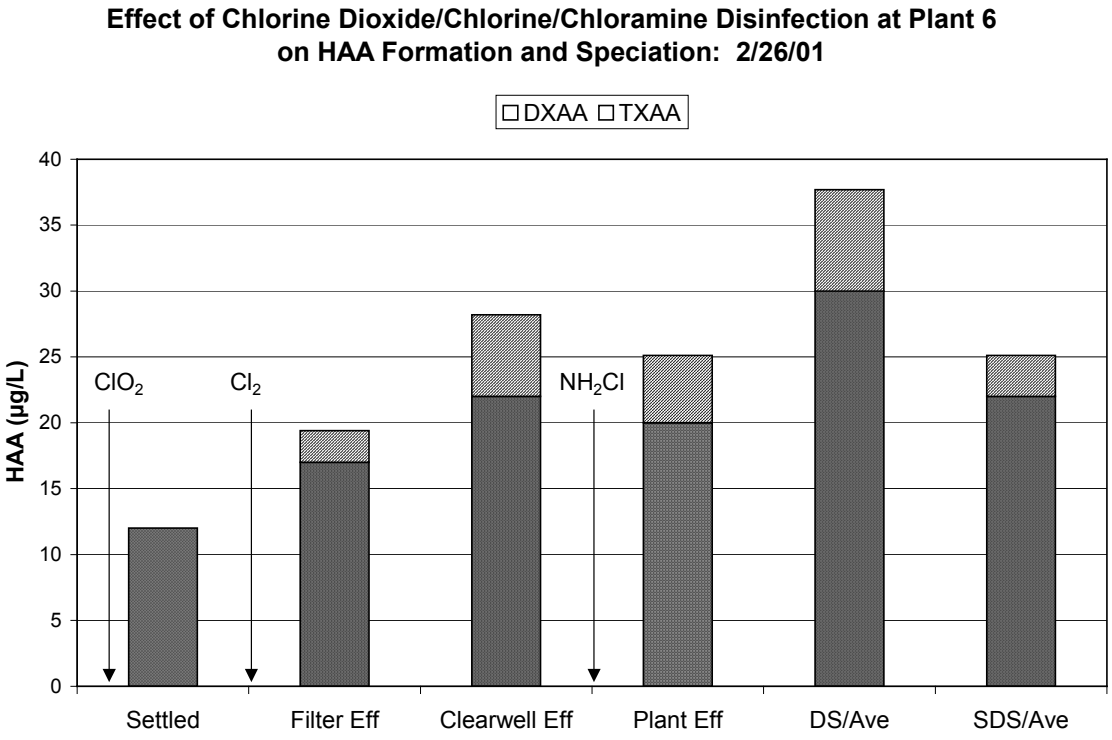


Figure 12



In the presence of chlorine, HAAs were formed in the plant 5 SDS testing (Figure 13). The SDS/average samples for plant 5 in November 2000 - August 2001 were held for three days. The increase in formation of the DXAAs was much higher than for the TXAAs, which may be due (in part) to the ability of ozone to better destroy TXAA precursors. In the presence of chloramines, HAA concentrations were typically stable within analytical variability in the plant 6 SDS testing (Figure 13). The SDS/average samples for plant 6 in November 2000 - August 2001 were held for four days.

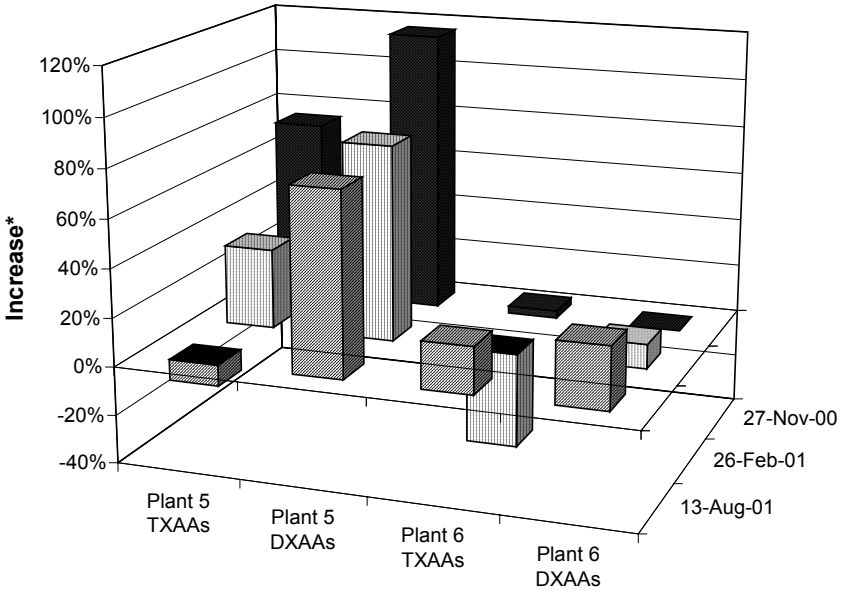
In addition to the target HAAs, other haloacids were detected in selected samples by the broadscreen GC/MS methods (Table 17). Plant 6—which had 0.04 mg/L bromide in February 2001—produced two other chlorinated acids (i.e., di- and trichloropropenoic acid). These were detected following the chlorine dioxide disinfection. A different chlorinated acid was detected at plant 5 after post-chlorination (3,4,4-trichloro-3-butenoic acid).

UNC detected 3,3-dichloropropenoic acid in finished waters from several samplings (plant 5 and plant 6, November 2000; plant 6, August 2001; and plant 5, April 2002). Levels ranged from 0.7 to 4.7 µg/L in the finished waters, and generally increased in concentration in the distribution system.

Haloacetonitriles. In other research, haloacetonitriles (HANs) have been found to be produced at approximately one-tenth the level of the THMs (Oliver, 1983). This was also generally observed in the plant 5 and plant 6 samples (Figure 14). Trichloroacetonitrile (TCAN)—an Information Collection Rule (ICR) DBP—was not detected. Likewise, the

Figure 13

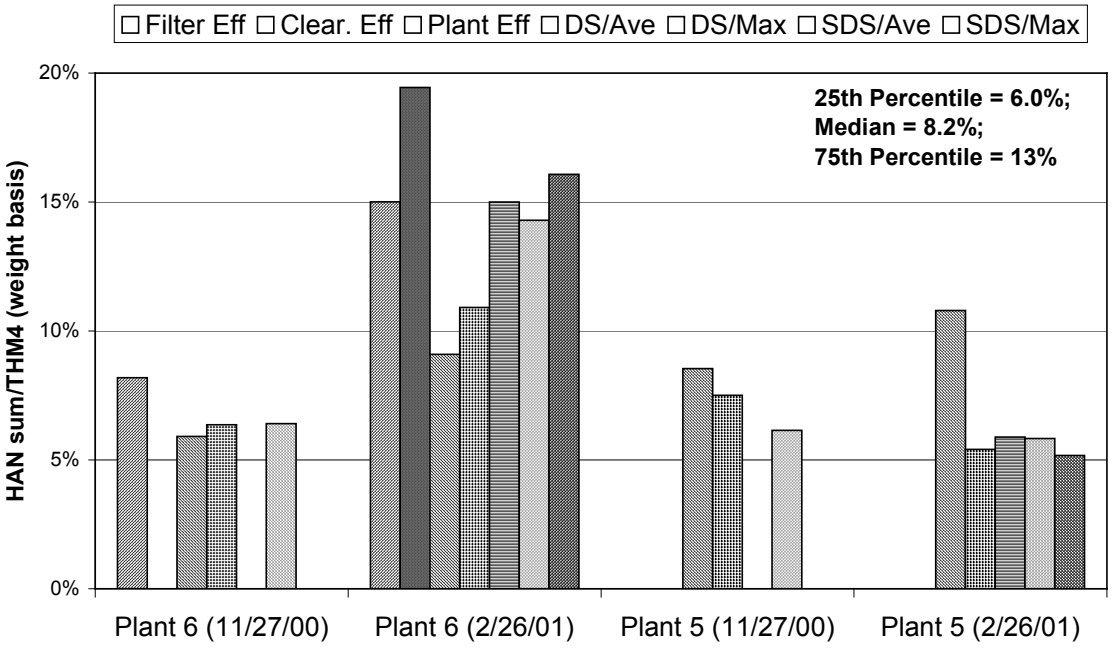
Impact of Residual Disinfectant on Formation of Haloacetic Acids in Simulated Distribution System Samples with Average Detention Time: Chlorine at Plant 5, Chloramines at Plant 6



*Negative value = decrease in concentration rather than an increase

Figure 14

Relationship of the Sum of HANs (up to 6 Species) to THM4 at Plant 5 and Plant 6

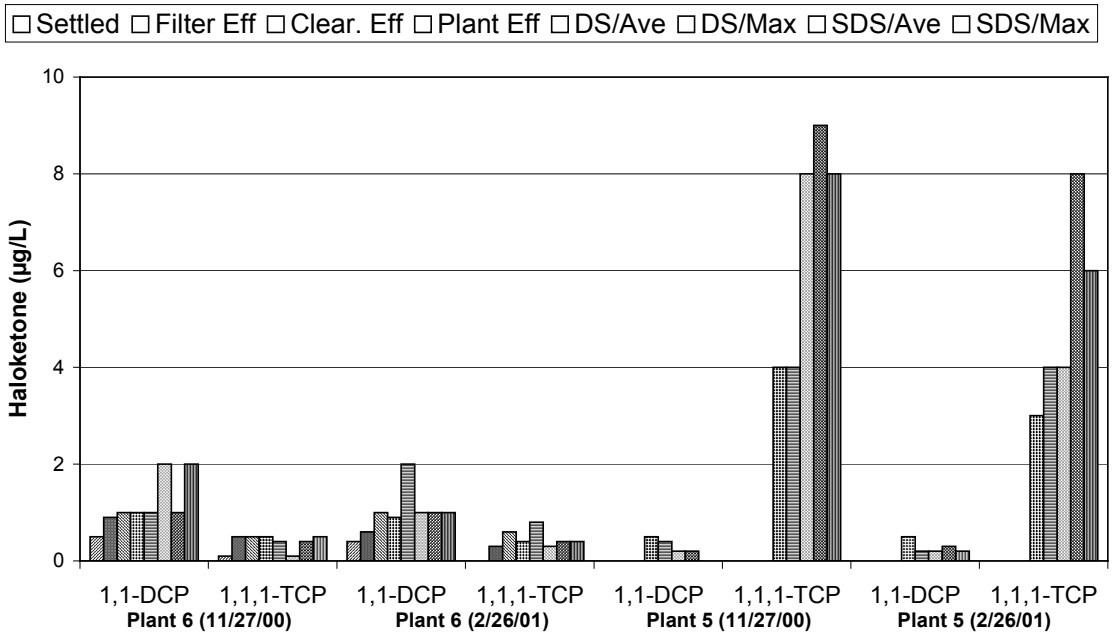


brominated analogues of TCAN were not detected in the plant 5 samples. However, at plant 6, dibromochloroacetonitrile was detected in an SDS sample in October 2001 and tribromoacetonitrile was detected in February 2001 by the broadscreen GC/MS methods (Table 17). In addition, sub-µg/L levels of another target HAN (i.e., chloroacetonitrile) were detected in selected samples at both utilities.

Haloketones. The level of 1,1,1-trichloropropanone (1,1,1-TCP)—which is a precursor to chloroform formation—was higher at plant 5 (Figure 15). More of this haloketone (HK) formed with free chlorine than with chloramines. The level of 1,1-dichloropropanone (1,1-DCP) was typically higher at plant 6 (Figure 15). The latter compound was often detected in the settled water after chlorine dioxide disinfection. Thus, at plant 6, chlorine dioxide and chloramines were found to be better at controlling the formation of 1,1,1-TCP (and THMs and TXAAs) than the formation of 1,1-DCP (and DXAAs).

Figure 15

Effect of Ozone/Chlorine Disinfection at Plant 5 and Chlorine Dioxide/Chlorine/Chloramine Disinfection at Plant 6 on the Formation of Haloketones



In addition to the formation of low levels of HK compounds from the ICR (i.e., 1,1-DCP and 1,1,1-TCP), low levels of some of the target HKs were detected in selected samples. In addition to the target HKs, other HKs were detected in selected samples by the broadscreen GC/MS methods (Table 17). A number of these HKs were analogous to the di- and tetrahalogenated target HKs, except that these were mixed bromochloro species.

Haloaldehydes. In addition to the formation of chloral hydrate (trichloroacetaldehyde)—an ICR DBP—dichloroacetaldehyde was formed. The level of chloral hydrate was higher at plant 5. More of this DBP formed with free chlorine than with chloramines. On the other hand,

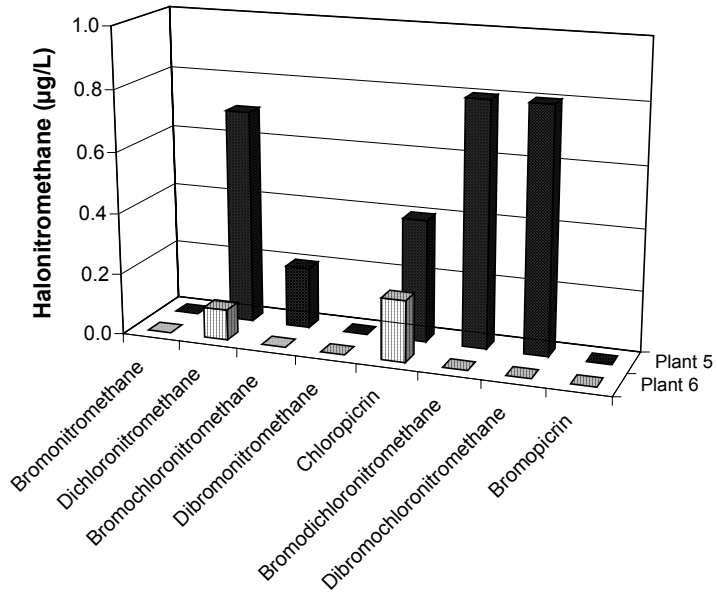
dichloroacetaldehyde was often higher in concentration at plant 6. In addition, brominated analogues of both of these haloacetaldehydes were detected in selected samples.

In addition to the target haloaldehydes, two other haloaldehydes were detected in selected samples by the broadscreen GC/MS methods (Table 17). Another brominated aldehyde (2-bromo-2-methylpropanal) and an iodinated aldehyde were detected (tentatively identified as iodobutanal). This is the first report of an iodoaldehyde as a DBP in drinking water. High resolution mass spectrometry confirmed the presence of the iodine in the structure of this molecule, and also its overall empirical formula (C_4H_7OI, molecular weight of 198). At this point, the identification is tentative, however—it is highly likely that the molecule is an iodo-aldehyde with four carbons, but the exact isomer assignment cannot be determined by its mass spectrum. An attempt to obtain synthetic standards of iodobutanal forms is currently underway in order to obtain a confirmed assignment.

Halonitromethanes. Low levels of chloropicrin (trichloronitromethane) (an ICR DBP) were detected. Other halonitromethanes (HNMs) were detected in selected samples. The levels of chloropicrin and the bromine-containing trihalonitromethanes were higher at plant 5 (Figure 16). Other research has shown that pre-ozonation can increase the formation of chloropicrin upon post-chlorination (Hoigné and Bader, 1988). Similar to the THM speciation in the plant effluent samples in August 2001 (Figure 7), in terms of the trihalonitromethanes, mixed bromochloro species predominated at plant 5, whereas the trichloro species was the only trihalonitromethane detected at plant 6 on that sample date (Figure 16).

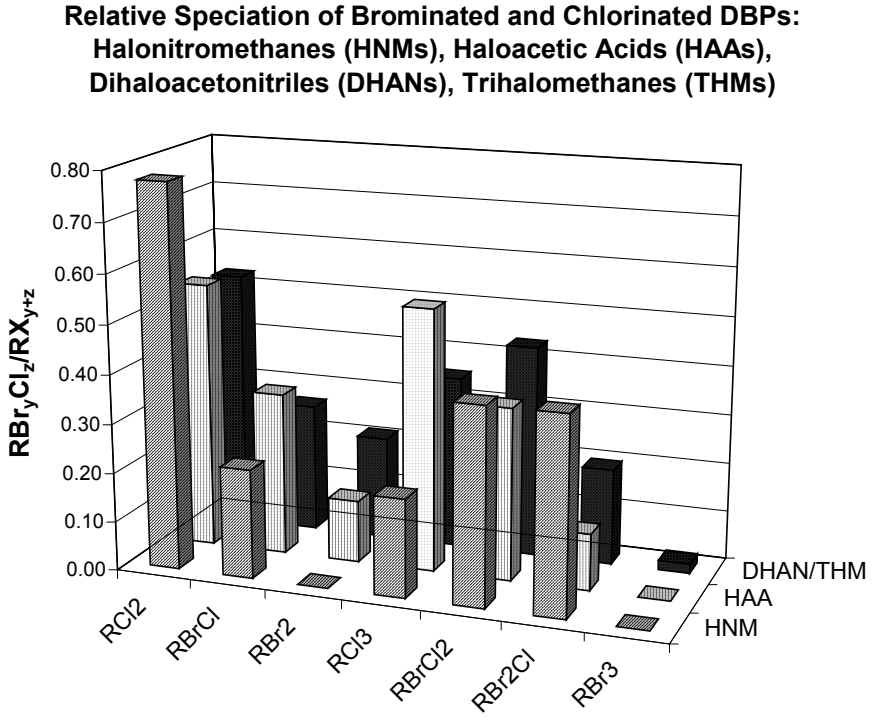
Figure 16

Impact of Ozonation/Chlorination at Plant 5 versus Chlorine Dioxide/Chlorine/Chloramine Disinfection at Plant 6: Plant Effluents (August 13, 2001)



The relative speciation of brominated and chlorinated HNMs (for the di- and trihalogenated species) was compared to the HAAs, THMs, and the dihaloacetonitriles (DHANs) for the August 2001 data. Each DBP can be abbreviated based on the number of halogens and the speciation of the halogens as follows: RBr_yCl_z, where the number of bromine and chlorine atoms are y and z, respectively, and R corresponds to the remainder of the DBP molecule (i.e., carbon, hydrogen, oxygen, and nitrogen atoms). The concentration of each DBP was "normalized" by dividing its concentration by the sum of the concentrations of all of the DBPs for that "subclass" of DBPs (RX_{y+z}) (Figure 17). For example, the concentration of DCAA was divided by the sum of all the DXAAs.

Figure 17. Plant 5 effluent (August 13, 2001)



For the dihalogenated DBPs (RX_2), the dichlorinated species represented 53 to 78 % of the sum of the dihalogenated DBPs in that class of DBPs. The bromochloro species represented 22 to 33 % of the class sum, and the dibromo species represented 0 to 21 % of the class sum. For the trihalogenated DBPs (RX_3), the trichlorinated, bromodichlorinated, dibromochlorinated, and tribrominated species represented 20 to 53 %, 35 to 43 %, 12 to 40 %, and 0 to 2 % of the class sum, respectively. For the THMs, HAAs, DHANs, and HNMs, there was a similar relative speciation of brominated and chlorinated DBPs for the dihalogenated species and a similar relative speciation of brominated and chlorinated DBPs for the trihalogenated species.

Halogenated furanones. Tables 21 and 27 show the results for halogenated furanones in the August 2001 and April 2002 samplings for plant 5 and plant 6. Data are included for 3-chloro-4-(dichloromethyl)-5-hydroxy-2[5H]-furanone, otherwise known as MX; (E)-2-chloro-3-(dichloromethyl)-4-oxobutenoic acid, otherwise known as EMX; (Z)-2-chloro-3-

(dichloromethyl)-4-oxobutenoic acid (ZMX); the oxidized form of MX (Ox-MX); the reduced form of MX (Red-MX); brominated forms of MX and EMX (BMXs and BEMXs); and mucochloric acid (MCA), which can be found as a closed *ring* or in an *open* form. Results are displayed graphically in Figures 18 and 19.

The combination of ozonation and biofiltration (with GAC filters) removed MX and MX-analogue precursors in plant 5, whereas chlorine dioxide pretreatment at plant 6 did not. At plant 6, intermediate chlorination and chloramine post-disinfection produced MX and MX-analogues (Tables 21 and 27). In August 2001, MX was not detected at the plant 6 filter effluent, whereas it was detected in the plant 6 effluent (310 ng/L) (Figure 18). Alternatively, EMX was detected at the plant 6 filter effluent (230 ng/L), but it was not detected in the plant effluent. EMX is the *open* ring analogue of MX, and these two halogenated furanones are in equilibrium with each other. It appears as if EMX may have been converted to MX between the plant 6 filter effluent and the plant effluent.

In the second sampling of plants 5 and 6 (4/15/02) for halogenated furanones, brominated MX-analogues were also measured, but did not appear, except in low concentrations (up to 50 ng/L) (Figure 19), within plant 6 due to the low concentration of bromide (0.06 mg/L) in the source water. The reduced form of MX (red-MX) increased in concentration from the filter effluent (40 ng/L) to the plant effluent (580 ng/L) at plant 6 due to residual chloramines (3.2 mg/L) reaction with TOC (3.88 mg/L). Mucochloric acid (MCA open) was detected in the plant effluent (310 ng/L) of plant 5 due to the filter effluent chlorine (2.5 mg/L dose) and clearwell effluent chlorine (1.02 mg/L dose) reacting with the TOC (~3.5 mg/L) of the combined filter effluent.

Figure 18

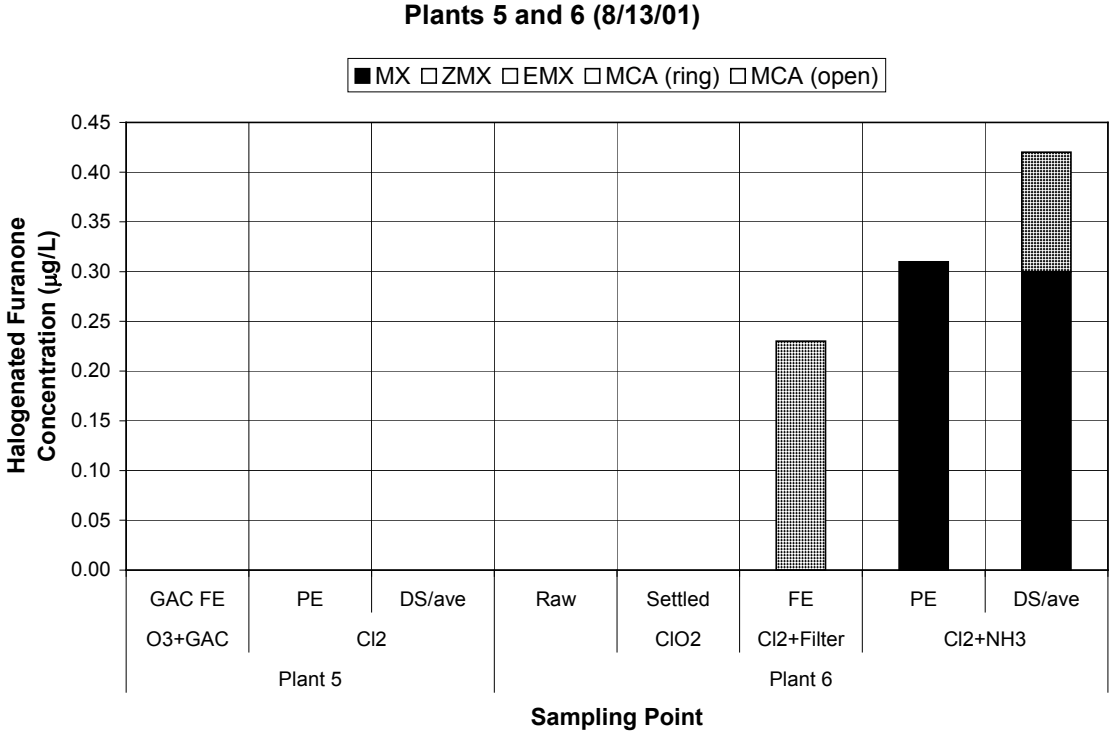
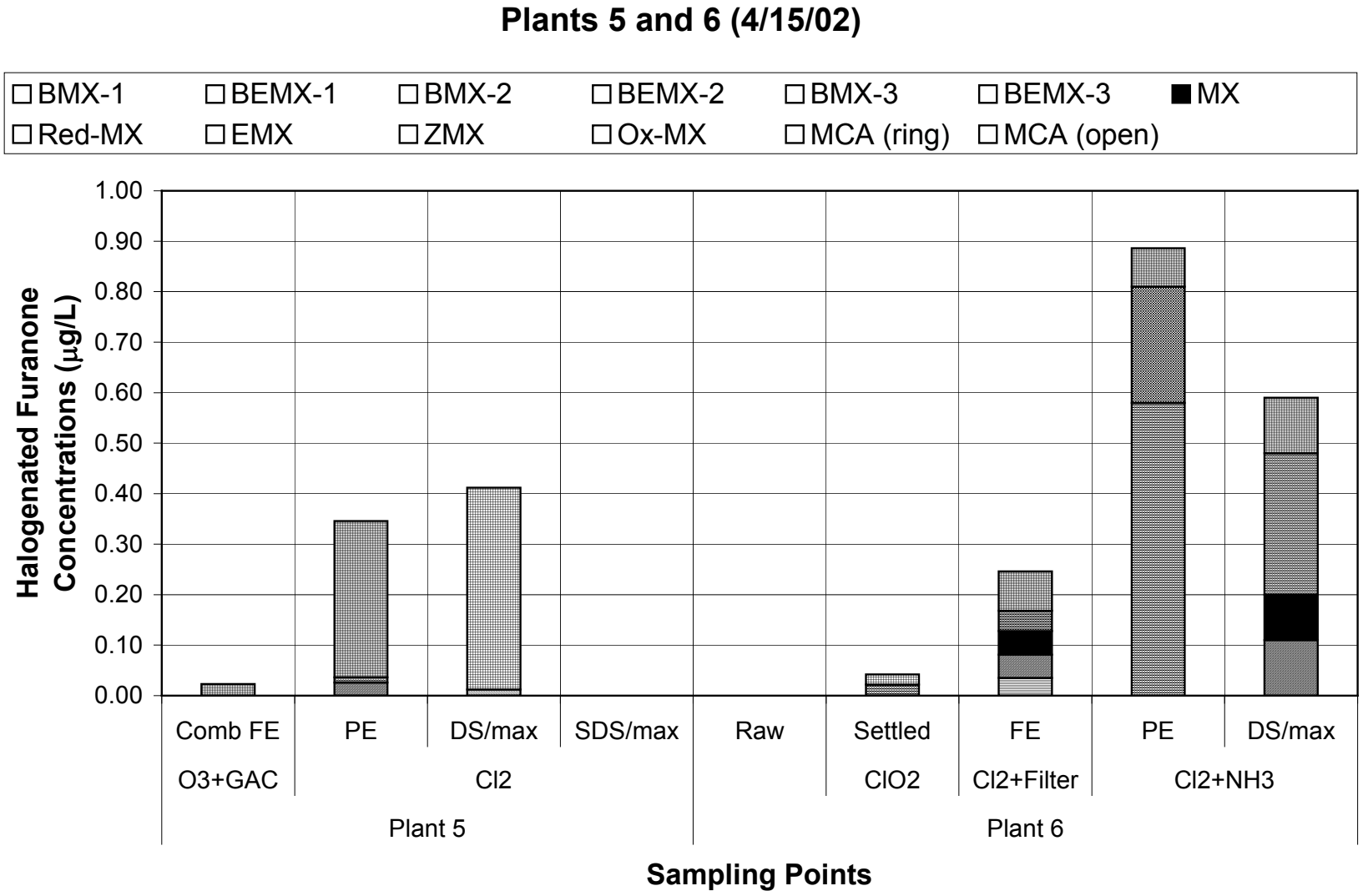


Figure 19


Plants 5 and 6 (4/15/02)
BMX-1
BEMX-1
BMX-2
BEMX-2
BMX-3
BEMX-3
MX
Red-MX
EMX
ZMX
Ox-MX
MCA (ring)
MCA (open)
Halogenated Furanone Concentrations (µg/L)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Comb FE
PE
DS/max
SDS/max
Raw
Settled
FE
PE
DS/max
O3+GAC
Cl2
ClO2
Cl2+Filter
Cl2+NH3
Plant 5
Plant 6
Sampling Points

Volatile Organic Compounds. Methyl ethyl ketone (MEK) was detected in the raw water of both plants on August 13, 2001 at concentrations of 3-7 µg/L. The level of MEK decreased through the treatment plant and in the distribution system. MEK was detected in the raw water on October 22, 2001 and April 15, 2002 at 0.6-0.7 µg/L and in other selected samples at similar concentrations. Methyl *tertiary* butyl ether (MtBE) was detected in the raw water of both plants on August 13, 2001 at a concentration of 0.3-0.4 µg/L. The level of MtBE was unchanged through the treatment plant. MEK is an industrial solvent and MtBE is a gasoline additive.

Other Halogenated DBPs. A few additional, miscellaneous halogenated DBPs were also detected. UNC methods detected dichloroacetamide at 1.5, 5.6, and 2.7 µg/L in finished water from plant 6 (11/27/00, 8/13/01, and 4/15/02) (Tables 14, 20, and 26). Dichloroacetamide was also observed in finished water from plant 5 at 0.5 µg/L in April 2002 (Table 26). Levels either increased or remained fairly steady in the distribution system and in SDS testing. Also, four additional haloamides-- monochloroacetamide, monobromoacetamide, dibromoacetamide, and trichloroacetamide—were found in finished water samples collected in April 2002 from both plants (Table 26). Bromochloromethylacetate was observed in November 2000 in finished waters from plant 6 (1.1 µg/L), but was not detected in the distribution system or SDS testing (Table 14), presumably due to degradation.

Broadscreen GC/MS analyses revealed the presence of hexachlorocyclopentadiene and dichloroacetic acid methyl ester in finished water collected from plant 6 in February 2001 (Table 17). These compounds were not observed in the corresponding raw, untreated water.

Non-Halogenated DBPs. A few non-halogenated DBPs were detected in finished waters from plant 5 and plant 6. Dimethylglyoxal was identified at 2.1 and 1.7 µg/L in finished waters from plant 5 and plant 6, respectively (November 2000, Table 14). It was also found in later samplings from both plants (Tables 20 and 26), and it did not appear to degrade in the distribution system. *Trans*-2-hexenal was also identified in waters from two samplings (Tables 14 and 26) and appears to be formed both by ozonation and treatment with chlorine dioxide. However, it does not appear to be stable; levels were diminished at the plant effluent.

Broadscreen GC/MS analysis revealed the presence of glyoxal and methyl glyoxal in both the ozone effluent and the finished water from plant 5 (Table 17). Also, decanoic acid and hexadecanoic acid were found in finished waters from plant 6 at levels significantly higher than in the raw, untreated water (Table 17).

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